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Chemical Engineering

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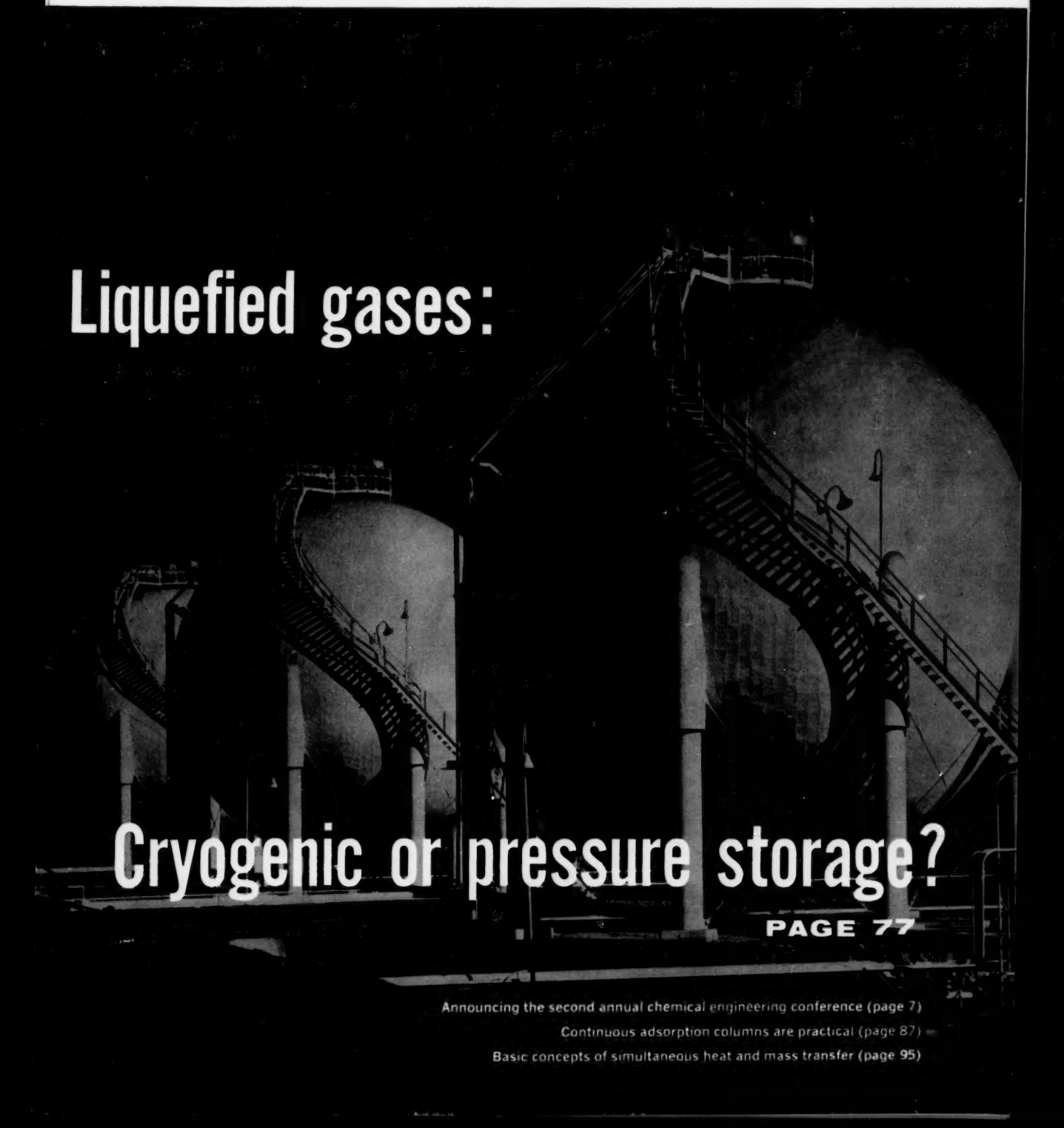

Liquefied gases:

Cryogenic or pressure storage?

PAGE 77

Announcing the second annual chemical engineering conference (page 7)
Continuous adsorption columns are practical (page 87)
Basic concepts of simultaneous heat and mass transfer (page 95)

CHECK How Many Ways EIMCOBELT® Filters Have Cut Processing Costs!

REDUCED PROCESSING COSTS	A chemical processor increased plant capacity 30% and reduced soluble loss 65% with the installation of an EimcoBelt continuous belt filter. Savings — over $200,000 a year!	✓
REDUCED CHEMICAL COSTS	In a wastes disposal operation an EimcoBelt filter replaced a standard drum filter, resulting in reduced need for chemical additives to condition the sludge for filtration. Savings — over $100 a day.	✓
REDUCED LABOR COSTS	In a dewatering process, two EimcoBelt filters replaced a battery of plate and frame filter presses, resulting in greatly reduced labor costs. Savings — $31,500 the first year.	✓
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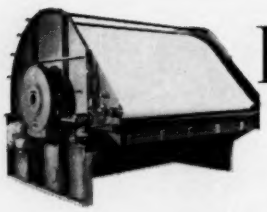
REDUCED DOWNTIME	No production shutdowns to clean blinded filter media, with EimcoBelt filters, even handling the most difficult slurries. Cloth change can be made in a half hour or less, on EimcoBelt filters.	✓



Find Out How Many Ways EimcoBelt Filters Can Cut Costs For You . . .

Ask the Eimco representative in your area to help you estimate savings in your plant with EimcoBelt filters. Write Eimco Filter Division for Bulletin FE-2053.

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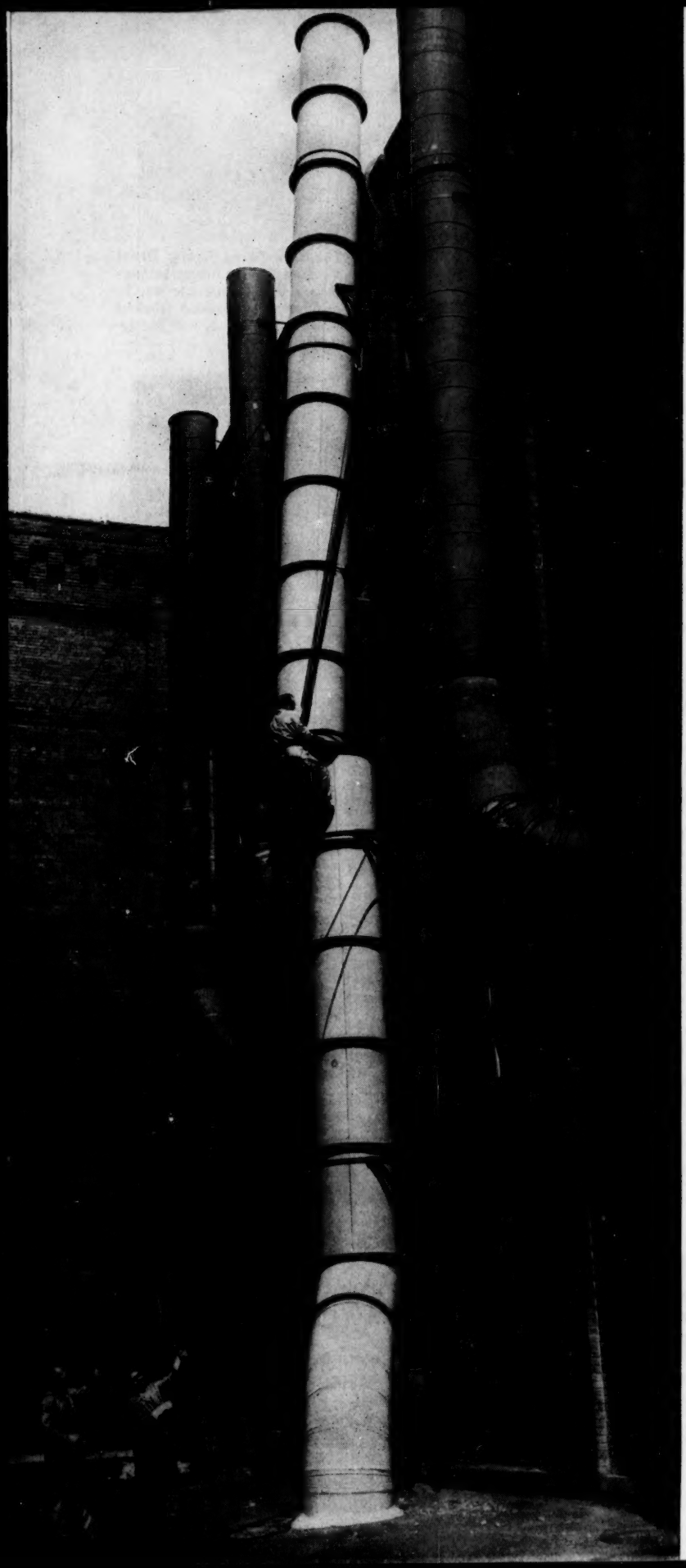

Koroseal breathes corrosive fumes without killing itself

Koroseal PVC won't corrode, can't rust or rot, is easy to fabricate and install

THAT 80-foot exhaust stack, being jockeyed into place, will carry away corrosive fumes from an automatic plater. Made of Koroseal rigid PVC, by B.F. Goodrich, it's expected to last at least 15 years. Pretty good service compared to the 3 or 4 years averaged by those corrosion-prone sheet metal stacks along side it.

Koroseal rigid PVC is ideal material for exhausting acid fumes because it does not corrode. It won't rust or rot, is unaffected by most acids, alkalies, salts, oils. That's why the Koroseal stack will save the cost of three replacements—will probably never need maintenance or repairs of any kind.

Because rigid Koroseal weighs only ¼ as much as steel, installation is easy and fast. Methods of fabrication and installing Koroseal are the same as with sheet metal. It can be machined, sawed, cut, drilled, punched, bent and formed. Sections can be joined by solvent-cementing, heat welding or with fasteners.

Though the initial cost of a Koroseal stack is higher than sheet metal, Koroseal actually saves money when you consider it lasts several times longer, costs less to install, and virtually eliminates maintenance and shutdowns.

For the full story on Koroseal's many advantages get in touch with a B.F.Goodrich distributor, or send for our catalog. *B.F.Goodrich Industrial Products Co., Dept. M-117, Akron 18, Ohio.*

Koroseal—T.M. Reg. U.S. Pat. Off.

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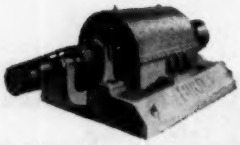
KOROSEAL RIGID PVC PRODUCTS

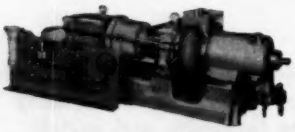
8 WAYS TO SEPARATE SOLIDS FROM LIQUIDS

•

BIRD BUILDS ALL EIGHT

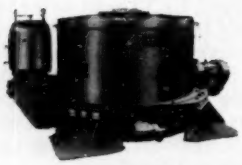


The Bird Continuous Solid Bowl Centrifugal comes in seven sizes and multiple design variations.



The New Bird "Compact" Centrifugal with 6" solid bowl runs at speeds up to 6000 RPM. It may be arranged for pressurized operation, as shown.

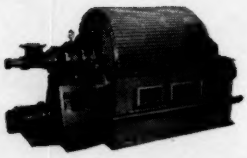
The Bird Continuous Screen Type Centrifugal deliquors and washes crystals or granules from heavy slurries.



The Bird-Humboldt Oscillating Screen Centrifuge dewaters plus 65 mesh solids with almost no degradation or loss of solids.

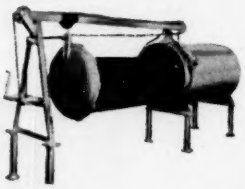
The Bird Research and Development Center has the centrifugal and filtration engineers and pilot-scale test facilities to come up with the right answer whatever

- the volume
- the solids characteristics
- the liquid characteristics
- the feed consistency
- the fluctuations in feed
- the feed temperature
- the wash requirements
- the desired end results



The Bird-Young Rotary Drum Vacuum Filter achieves extraordinary throughput per sq. ft. of filter area; provides efficient wash; ideal for low cost, fume-tight operation.

The Bird-Prayon Tilting Pan Horizontal Vacuum Filter combines big capacity with super-efficient, multi-stage washing. Filter areas from 27 to 516 sq. ft.



The Bird Pressure Leaf Filter offers large filter area, high rate of flow, working pressures up to 75 psi, corrosion resistant construction.

The Bird Suspended Batch Centrifuge is custom built for heavy duty service, with 26", 40", or 48" basket, perforate or imperforate; fume-tight or explosion proof if desired.

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SOUTH WALPOLE, MASSACHUSETTS

BUILDERS OF THE COMPLETE LINE OF SOLID-LIQUID SEPARATING EQUIPMENT

Operators of the Bird Research and Development Center for pilot-scale testing to determine the correct equipment for the job. Yours to use.

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Chemical Engineering

May 29, 1961

CHEMICAL TECHNOLOGY FOR PROFIT-MINDED ENGINEERS

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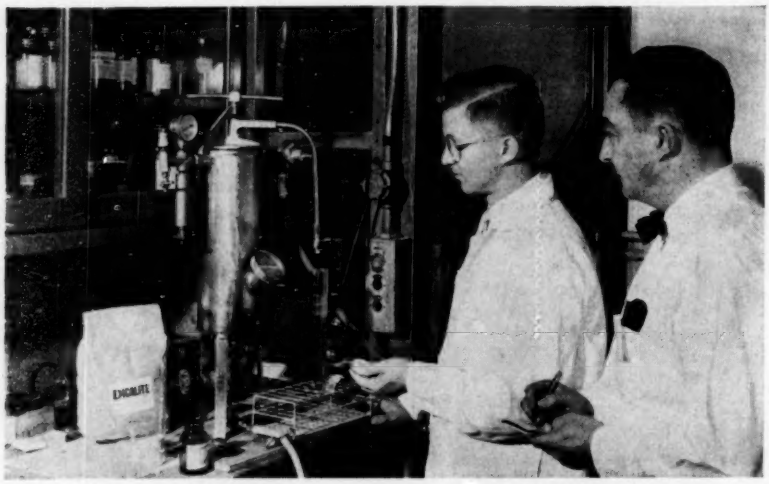
DICALITE® TECHNICAL REPORT

DICALITE DEPARTMENT • GREAT LAKES CARBON CORPORATION • 612 SO. FLOWER ST., LOS ANGELES 17, CALIFORNIA

Why Antibiotics Producers Filter with Dicalite

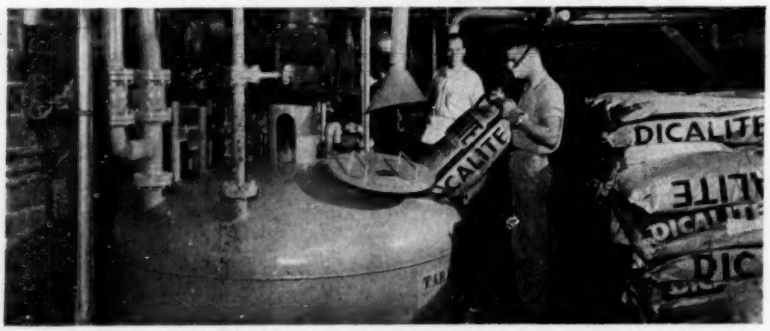


Dicalite Filteraids meet two major requirements in antibiotics production—(1) large volumes of fluid must be filtered, and (2) exceptional purity is required in the final product. Thus, they have long been used by many producers of penicillin, aureomycin, streptomycin and other drugs.

The consistent uniformity in each of the many Dicalite diatomite and perlite filteraids is an important factor, since it provides known performance characteristics in these critical processes.

Dicalite's new perlite filteraids are remarkably efficient in handling high solids content fluids, and provide high resistance to cake cracking in rotary vacuum precoat filtration, extensively used in pharmaceutical processing. Because of their light weight, Dicalite perlite filteraids give up to 25% greater filtering capacity per pound, resulting in savings in filteraid usage of 20 to 30%. They are available in a complete range of grades.

Dicalite technical service engineers will be happy to advise with you on the application of Dicalite filteraids to your individual needs in filtering any type of liquid.



At the Cherokee Plant of Merck & Co., Inc. at Danville, Penna., Dicalite is being used to aid the filtration of an antibiotic fermentation broth.

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Roger W. Hess

Dicalite's "Man On The Spot"

Working on filtration problems with customers' technicians in their laboratories is nothing new to Roger Hess, shown at left checking flowrate in a filtration test in a Merck laboratory, for Roger is a veteran of more than 25 years in the filtration field. Included were 12 years work with filter manufacturers, leading him to his present role of filteraid engineer. His interest in his work is indicated by the title of one of the papers he has contributed to chemical publications – "Filtration In My Blood."

Graduating from Brooklyn Polytechnic Institute with a degree in Chemical Engineering, Hess spent several years with chemical equipment manufacturers before getting into the specialized area of filtration. He counts 3 years laboratory work as being especially important in his present work. A member of the honorary fraternity, Phi Lambda Upsilon, he is active also in the American Chemical Society, the American Institute of Chemical Engineers, the Baltimore Chemical Club, and other technical societies in the paint, brewing, electroplating and chemical fields.

TECHNICAL LITERATURE

on Dicalite Filteraids is available on request. Bulletin B-14 discusses the principles and operating practices of filteraid filtration, and its applications in many industries.

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Chemical Engineering
MAY 29, 1961

highlights of this issue

DESIGNING A FLUIDIZED ADSORBER

Although the Wisconsin-FMC process for high-temperature fixation of nitrogen proved to be uneconomic, it yielded, as a byproduct, valuable know-how in several areas of technology. One such area is continuous adsorption in shallow, fluidized beds. Here is the first detailed report (p. 87) on this operation, by Food Machinery's Gene Ermenc. Giving due attention to the critical problem of adsorbent attrition, the author shows how fundamental engineering principles of countercurrent mass-transfer operations apply to design of fluidized adsorbers.

ARE YOUR DEPARTMENT'S COSTS MEANINGFUL?

Wingate H. Richardson is back, his many fans will be happy to learn. His latest article (p. 108) puts production supervisors on guard against skulduggery—or just plain honest mistakes—in the costs allocated to their departments. "If you want to operate at a profit, you must know what your costs are," reasons W.H.R.

CRYOGENIC OR PRESSURE STORAGE?

Should you store liquefied gases at ambient temperature under pressure, or at atmospheric pressure under refrigeration? Recent trends have favored low-temperature, low-pressure storage. N. R. Hower, Chicago Bridge & Iron Co., presents (p. 77) an engineering-economic analysis of liquefied gas storage that will help you decide which system is best under any given set of conditions.

For an important editorial message.....SEE PAGE 7

ONE OF A SERIES OF CHATS ABOUT CONSERVATION AND CONTROL OF HEAT

SARCO TOPICS

A FAMOUS FLUID WITH TEMPERATURE CONTROL PROBLEMS

Wine has never been properly appreciated by enough people. Many think you simply press grapes, bottle the juice, and wait a while to create wine. Even those who pride themselves on their knowledge of this age-old drink are seldom aware of the artful thermal engineering required. Pasteurizing wine is actually one of the most tricky and delicate feats in the field of liquid processing.

Take temperatures. Wine must be pasteurized at 140°F. Those are the facts of life in the world of wine. They might not seem too difficult to live with unless you're in the wine or chemical processing business.

Take New York's Monarch Wine Company, producers of Manischewitz Wine. Their Problem: how to maintain the 140° temperature in the heat exchangers despite wide variations in the rate of wine flow. These variations, between 5 to 60 gallons per minute, result from slowdowns and recoveries in the bottling process. Problem: entire system must be capable of complete shutdown when necessary. Problem: wine temperatures must be raised to 140° as rapidly as possible, sometimes an immediate jump of 100°

Attracted perhaps by aspects of the situation that had little to do with pure science, Sarco engineers applied the collective experience of Sarco technology to the solution of this serious problem. The result for Monarch: the *degree of control* the process demanded—achieved through the excellent use of Sarco Temperature-Pressure Regulators, Float Thermostatic Steam Traps, Thermo-Dynamic Steam Traps, and Pipeline Strainers.

Sarco engineers, ever resourceful, divided each of the two large Cherry-Burrell plate-type heat exchanger units into two separate sections with a blank baffle plate, each with a separate Sarco control. Thermal sensing bulbs were installed in wine discharge and throttling controls hooked into steam supply. As demand fluctuates, one or both regulators function to maintain the 140° temperature.

In higher demand, both regulators are operative; as demand drops and flow decreases, only one regulator supplies steam. Pasteur himself would have been elated.

Each of six smaller capacity shell-and-tube heat exchangers required only one regulator, with the sensing bulb inserted into the outlet side of the wine filled shell, and the regulator throttling steam supply to the tube section. Thus, by controlling flow of steam to the exchangers on the basis of pressure and temperature, the Sarco regulators were able to maintain the temperature of the wine at precisely 140° regardless of fluctuations in demand or supply rate. Whew! A lot of engineering went into those two sentences.

From here on it's downhill. To secure complete cut off of the steam supply during scheduled shut-downs of the bottling run, solenoid valves were provided to supplement normal modulating action of the controls. To discharge widely varying loads of condensate continuously and remove immediately all air and incondensible gases, Sarco Float Thermostatic Steam Traps were installed on all condensate outlets. On the drips before each control valve a Sarco Thermo-Dynamic Steam Trap was installed to insure delivery of dry steam. Sarco Pipeline Strainers were installed before all steam traps and valves to protect them against damage by any foreign bodies. And thus ends a classic story of the grape.

Still, this story has been condensed far too much, really, and we feel you've been cheated out of the story's more delicious details. You needn't be, however. We've printed the facts in detail for posterity and you in Sarco Case History 185, complete with drawings that practically make it a do-it-yourself kit. If you would like a copy, we will be flattered to receive your request, and dispatch it with dispatch.

WE'RE ALWAYS IN . . . AND THE WELCOME MAT'S OUT

We always take it for granted that if you are going to be in the vicinity of our plant you'll phone or drop us a line so we can invite you to visit us. You'll find that our factory in Bethlehem, Pennsylvania, is on many well-travelled routes and that our steam laboratory has much to offer in interest and helpfulness. Forgive us for being immodest, but the lab is the most up-to-date of its kind in the country.

When you visit us, don't allow yourself to get sidetracked by the drill presses and automatic lathes. We're proud of this equipment but you've probably seen metal mutilated before, and it's our steam laboratory that's unique. We promise you a good show, and if you have any problems, bring them along. We'll solve them while you wait.

ANYONE FOR KEY CHAINS?

We seem to have these key chains. Want one? They're much more convenient than a case. A tiny replica of a Sarco Thermo-Dynamic Steam Trap, Type TD-50 is attached, but you can always remove it if you find it too commercial. There must be many things you could use these chains for. Fishing sinkers? Lengthening a light cord, maybe? Anyway, if your Sarco representative is out, write in.

Pardon our monopolizing the conversation in this series of paid communiques, but we're trying our best to interest you in certain subjects that concern us both—to the point where you'll communicate.

6354

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STEAM TRAPS • TEMPERATURE CONTROLLERS
STRAINERS • HEATING SPECIALTIES

New Trends in Chemistry

A two-day conference on "New Trends in Chemistry" will be held in Chicago on October 11 and 12 under the joint sponsorship of Armour Research Foundation and *Chemical Engineering.*

Technical program will consist of thirteen invited papers covering such topics as plasma chemistry, inorganic polymers, organic semiconductors, nonaqueous chemistry, kinetics and catalysis. Papers will be pitched primarily at chemical engineers who have been out of college for five years or more. Conferees will have ample opportunity for relaxed, informal discussions.

This will be the second conference of its type that we have cosponsored. Our maiden venture was the highly successful "Conference on the New Chemical Engineering," cosponsored with Midwest Research Institute in Kansas City last November. (Papers from that program were published in *CE* in December and January; reprints are available, see p. 153.)

Why should we, a publication, get into the business of programming "live" technical meetings? Don't the technical societies do an adequate job? Aren't there too many meetings already?

One thing is sure: we don't do it as an easy way to get good papers for publication; it's an extremely difficult and expensive source of manuscripts. And there is no profit motive. Conference fee is budgeted barely to cover costs.

Stated simply, we saw a job that needed to be done and decided to do it. Most technical society meetings are too big, too diverse, too full of distractions to concentrate on a given subject and explore it in both breadth and depth. And programs are assembled, in most cases, by part-time volunteers.

We feel we are well qualified to undertake this type of activity. We can draw upon 59 years' experience in serving the technical information needs of the chemical engineering profession. We can bring to bear the combined talents of more than twenty technically trained, industry-experienced individuals on our own staff. With the assistance of a capable cosponsor, we can provide a service unique in the chemical engineering field.

Feedback from those who attended the Kansas City conference has confirmed our reasoning. A post-conference survey of all registrants showed that 95% of them found the conference "very useful" or "moderately useful." Most of them suggested topics for future conferences, and out of these suggestions came the subject ideas for the upcoming Chicago conference.

Watch for further announcements on program content, registration and hotel reservations. Meanwhile, reserve the dates, October 11-12, on your calendar.—Cecil H. Chilton

AT ORTHO PHARMACEUTICAL CORP.

Fast, easy cleaning of liquid dispersion bar and "Twin-Shell" interior speeds-up formulation changeover at Ortho.

P-K LIQUID-SOLIDS BLENDER GRANULATES TABLET FORMULATIONS IN A SINGLE STEP

PRE-BLENDS, DISPERSES, GRANULATES

A 10-cubic foot Liquid Solids "Twin-Shell"* Blender pre-blends dry tablet powders, disperses liquids into solids, and granulates tablet formulations in a single production step for Ortho Pharmaceutical Corporation, Raritan, N. J. It replaces equipment requiring multiple step processing.

The P-K Liquid-Solids Blender was purchased, according to John Colligas, Director of Pharmaceutical Manufacturing, "as a result of pre-testing, which demonstrated the unit's ability to precisely blend and granulate our material as well as provide versatility and close quality control. We need these features because of the varied formulations in our new line of tableted products."

P-K PRE-TEST RESULTS CONFIRMED

Before installation, specially selected formulations prepared by Ortho were tested in the Liquid-Solids Blender at the P-K Pre-Test Laboratory in East Stroudsburg, Pa. These results then formed the basis for more extensive testing of the blender at the Ortho Plant. Here, tests centered mainly around the precision blending of dry materials and uniform dispersion of liquids and solids.

In a dry blending test, research engineers put 0.5 gms. of activated charcoal powder into 29 lbs. of Ferrous Calcium Citrate-with-lubricant mixture, through the charge openings of the P-K Blender. Following ten (10) minutes of operation, one-pound samples were taken from each of the three openings and subjected to microscopic examination. *Counts showed total dispersion had been achieved.*

In a similar liquid-solids test, 50 pounds of powdered lactose were pre-blended. Then, a dilute solution of methyl violet (0.1 gm./1,000 gm.), in 300 gm. increments, were poured in. After blender operated for ten (10) minutes, the powder was removed. *Inspection showed a more homogeneous wetting than that achieved in tests of other equipment.*

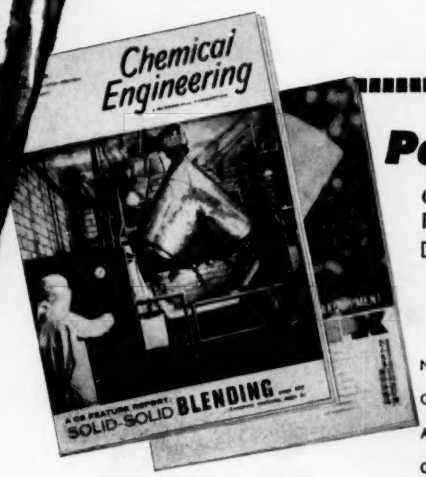
PRE-TEST BEFORE YOU BUY

Considering new solids processing equipment? You can justify investment—dispel or confirm doubts about purchase—at the P-K Pre-Test Laboratory.

Here, an unmatched range of solids processing equipment is available for testing: standard, intensifier, and liquid-solids "Twin-Shell" blenders, packaged tumble dryers; ribbon and doublecone blenders; and the new Solids-Processor* which telescopes up to ten operations in one unit. This equipment, plus the experience of engineers who have run thousands of resultful pre-tests can point the way to product improvement and process modernization.

Why not investigate? There's no cost or obligation. Write or dial George Sweitzer in Stroudsburg at HAmilton 1-7500 to discuss a pre-test date.

*patented



Patterson Kelley Chemical and Process Equipment Division
125 Burson Street, East Stroudsburg, Pa.

Gentlemen:
Please send me your (check one or both)—

☐ NEW REPORT ON SOLID-SOLID BLENDING. A 23-page cover article from *Chemical Engineering*, Aug. 8, 1960. Discusses blending theory, practice, equipment and economics.

☐ NEW P-K PROCESS EQUIPMENT CATALOG NO. 16-P. A 20-page bulletin, covers P-K pre-test services, lab and production blenders, vacuum tumble dryers, packaged resin-distillation pilot plants, heat exchangers.

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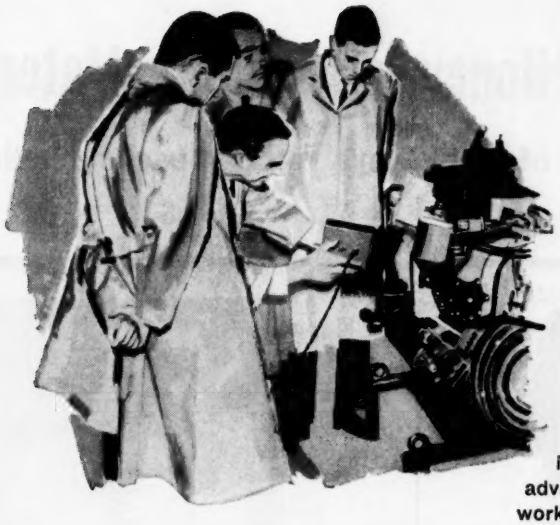
A sales organization especially trained to serve industrial and fleet customers . . . 74 District Offices and 13 Regional Offices . . . 4,100 warehouses and distribution points . . . 12 refineries . . . more than 2,000 products to serve you . . . this is American Oil Company.



The American Oil Company representative who calls on you receives special training in servicing industrial and fleet customers at our Sales Engineering School. His training begins with a concentrated course in petroleum product quality and application. According to a planned schedule, he returns for an advanced course and then again for post-graduate work. From our Marketing Technical Service Department, your American Oil representative draws assistance, when needed, from specialists who are recognized authorities in their fields. These specialists may be called in at any time to work with you on your lubrication problems. More than a thousand research scientists and technicians at our research laboratory support the effort of our representative to serve you. Their mission: To help your American Oil representative help you lower your maintenance costs and stretch your maintenance dollars. Learn more about American Oil, its men, its service, its products.

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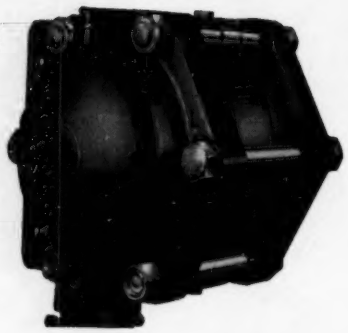
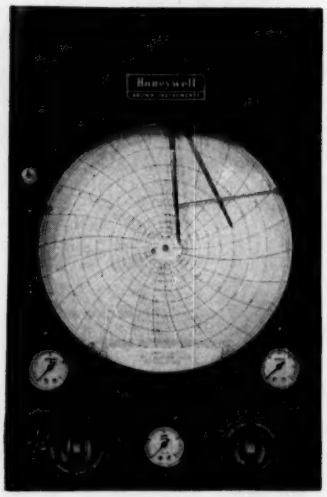
910 S. Michigan Ave., Chicago 80, Ill.



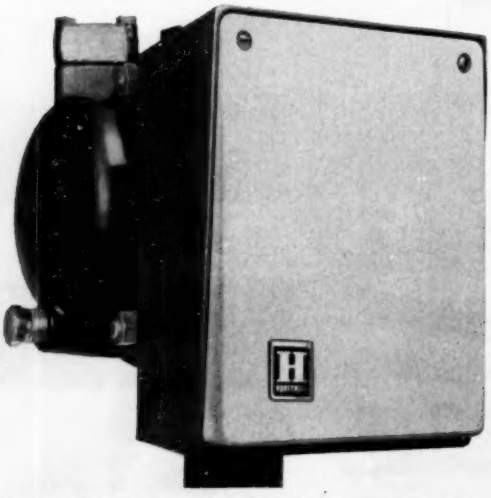
Honeywell Bellows Meter brings

Six of many ways you can use the bellows meter

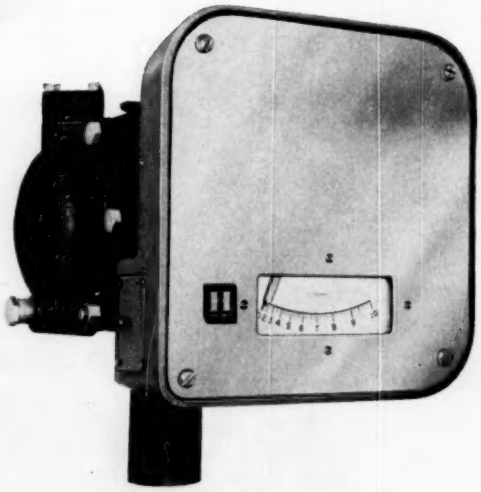
As a Recorder or Integrator—Recorders can have one, two or three pens, with the second and third pens actuated by thermometer or pressure elements. A single-pen recorder is shown above. You can get integration, too.
Write for Specification S 292-2a.



As Recording Controllers—You can get recorders with pneumatic ON-OFF, 10% *Throttlor*, 150% *Throttlor* with manual reset, or *Air-O-Line* (150% proportional band-plus-automatic reset) control. A single-pen pneumatic controller with integral bypass is shown above.
Write for Specification S 292-2a.

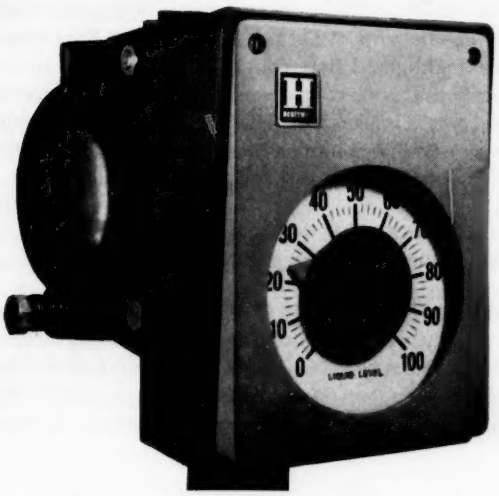


As a Non-indicating Pneumatic Transmitter—Use this non-indicating transmitter when you don't need indication at the point of measurement, and when the measured variable is to be transmitted to remotely located instruments.
Write for Specification S 230-1.



As an Electric Transmitter—You can use this *ElectriK Tel-O-Set* electric flow and liquid level transmitter with indicators, recorders, and controllers, with data handling systems, or with millivolt receivers. Field indication, as shown, is optionally available.
Write for Specification FS 301-7.

new versatility to flow or liquid level measurement



As an Indicating Pneumatic Transmitter—Gives you indication at the point of measurement, plus pneumatic transmission. Easy-to-read scale, and large indicating pointer. Case is only 4 by 7 by 9 inches.
Write for Specification S 230-1.

As a Dial Indicator—Six-inch dial indicator gives easy, accurate readings at point of measurement. This meter-indicator is designed specifically for field indication.
Write for Specification S 224-1.

You can use the Honeywell Bellows Flow Meter as a recorder, controller, indicator or transmitter . . . pneumatic or electric. Use it for accurate, low-maintenance metering of flow—for steam, water, gas, oil or other fluids—or for liquid level measurement. In all of its many forms, with all of its performance advantages and operating economy, it is the most advanced flow and liquid level meter available today.

Some outstanding features:

Stability—The meter body will operate over an ambient temperature range of —40° to 250°F. Over a range from —32° to 150°F. the accuracy will not change more than 0.5%.

Leakproof construction—Hydraulically formed stainless steel bellows eliminate any chance of leakage between fill and process fluid.

Quick, easy damping—Rectangular orifice pulsation check varies the speed of response over a ratio of 20 to 1. Adjustment is essentially linear and can be made from outside the meter body while the instrument is operating.

Sensitivity and accuracy are well within the required limits of measurement and control on applications for which these instruments were designed.

Convenience—Change range easily in the field by replacing a single range spring assembly. The meter body is self-venting when measuring liquids and installed below the flow line; self-draining when measuring gas and installed above the flow line.

There are models of the Honeywell Bellows Flow Meter available in many ranges, for every application. Your nearby Honeywell field engineer can give you complete details and help you select the correct model for your application. Call him today.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

Honeywell

First in Control

SINCE 1885

HONEYWELL INTERNATIONAL Sales and Service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

Turbulent liquid layers give remarkable heat transfer in DE LAVAL PLATE HEAT EXCHANGERS

In the past five years, plate heat exchangers have been rapidly outgrowing the limitations of earlier "special" all-stainless applications to become a common replacement for shell and tube units. Extreme compactness, high transfer efficiency, flexibility and trouble-free maintenance have justified this widening use. Installation requires only piping connections.

The benefits of De Laval Plate Heat Exchangers are highlighted here—but you will want to review our "case history" brochure detailing actual processing applications. Write for it, and for our catalog which describes models ranging from 500 to 500,000 lbs/hr capacity.

3 DEGREES OF ECONOMY
open new process possibilities

When the equipment must be all-stainless: At as little as one-third of the cost, including installation, De Laval PHE's do the job better than stainless shell and tubes. Most important, these lower costs and higher efficiencies now permit heat recovery

where the cost of stainless shell and tube exchangers previously made it impractical.

When partial-stainless is required: The *all* stainless De Laval PHE is almost always cheaper on an installed cost basis than stainless tubes in a steel shell—and offers many operating and maintenance benefits.

When carbon-steel is satisfactory: Even here, De Laval's all-stainless PHE's can return the higher unit cost through much cheaper installation and through annual savings because of their relative freedom from fouling and easier cleaning. Because they are free from corrosion problems and can be easily adapted or expanded to suit changing product needs, De Laval Plate Heat Exchangers are the *safe* way to handle *any* process heat exchange problem.

THE DE LAVAL SEPARATOR COMPANY

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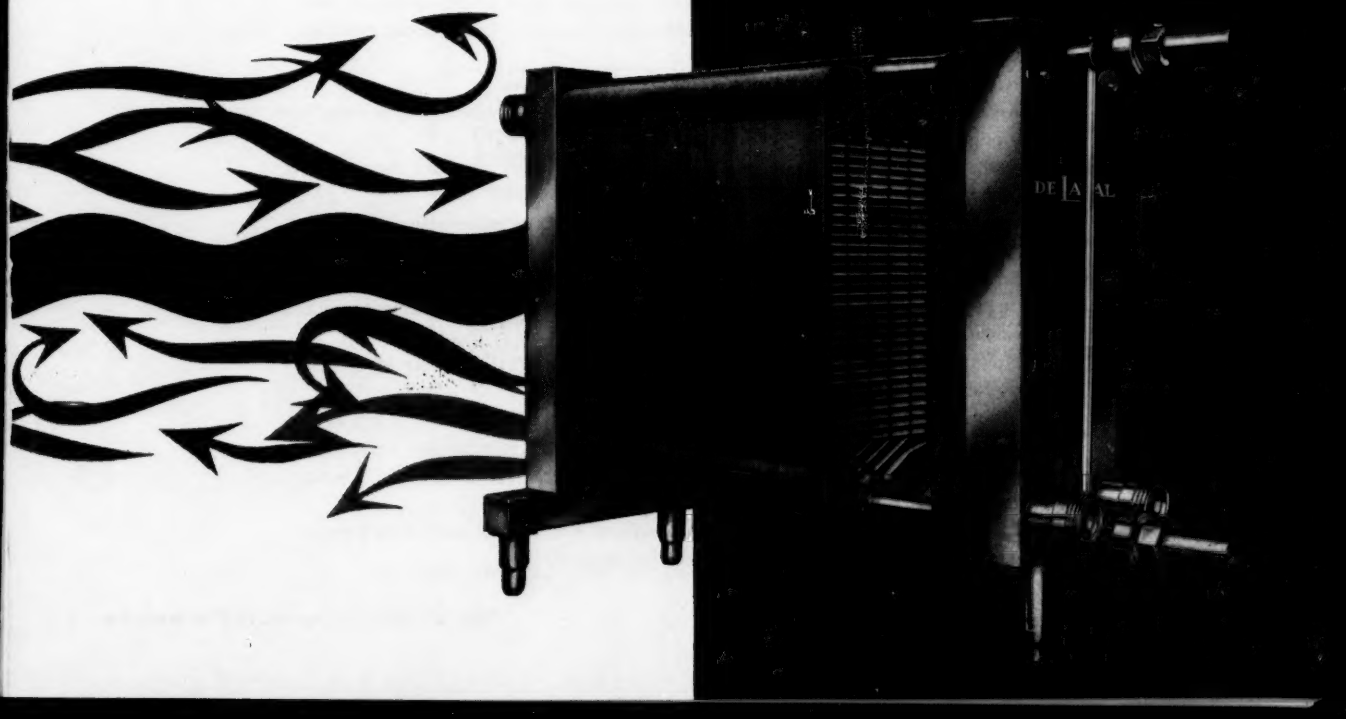
5724 N. Pulaski, Chicago 46, Ill.
201 E. Millbrae Ave., Millbrae, Cal.
Dept. CE-5.

DE LAVAL

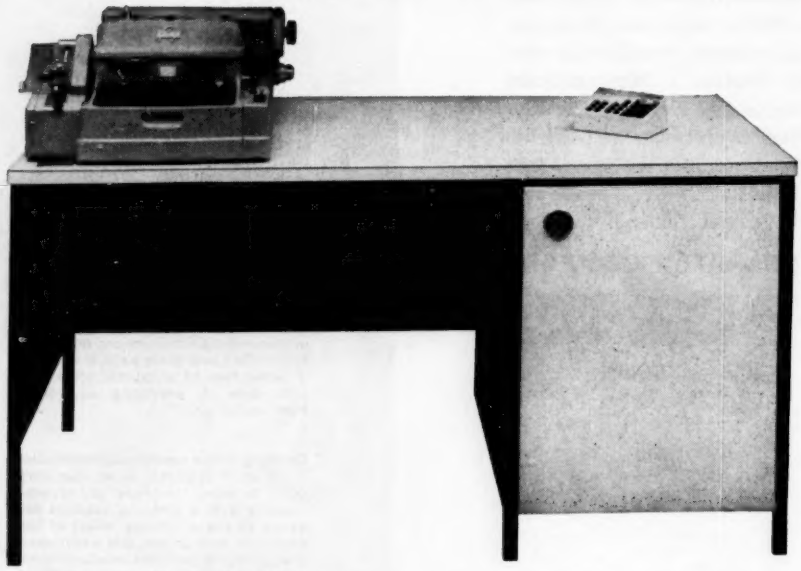


If you are using, or considering, a small-scale digital computer...

NOW, AT NO INCREASE IN COST, YOU CAN HAVE THE NEWEST & MOST VERSATILE SMALL-SCALE COMPUTER ON THE MARKET

RECOMP III

"More Computations Per Dollar"



Autonetics, producer of the world's first and finest solid-state, general-purpose, compact digital computer, now introduces a small-scale computer that is priced amazingly low.

It is Recomp III—a general-purpose solid-state digital computer for engineering, scientific, and industrial use.

Recomp III assures you of "more computations per dollar."

Recomp III offers you the largest word size and the largest memory of *any* small-scale computer.

Recomp III is the *only* low-priced computer that offers you two instructions per word.

Recomp III is the *only* low-priced computer that offers an index register as standard equipment.

Recomp III is the *only* low-priced computer that offers you built-in compacted floating point hardware and the new Facitape high speed paper tape reader and punch as optional features.

Now you can get Recomp's proven performance and quality for *no* more than you pay for lesser computers... and it is now available.

If your computer problems have grown and your computer hasn't; if you need a small-scale digital computer; now, for a lease price equal to what you are already paying or would expect to pay for an outdated computer, you can have the newest, most advanced, small-scale computer on the market—Recomp III.

For a convenient do-it-yourself comparison of Recomp III with your present computer or a competitive computer see the following page.

MAKE A POINT-BY-POINT COMPARISON OF YOUR PRESENT COMPUTER OR ANY SMALL-SCALE LOW-PRICED COMPUTER WITH THE NEW RECOMP III

	RECOMP III	COMPETITIVE COMPUTER
Monthly lease price	$1,495.00	$_____
Input Standard	Mechanical Reader	_____
	10 char/sec	_____
	Typewriter Engineering Keyboard	_____
	Typing Speed	_____
	Full Alphanumeric Input	_____
Input Optional	Capacitance Reader	_____
	600 char/sec (stops within a char)	_____
	Up to any type of four inputs	_____
Arithmetic Speeds—Fixed Point		
Add & subtract	.54 milsec (12 digits)	_____
Multiply	10.8 milsec (12 digits)	_____
Divide	11.3 milsec (12 digits)	_____
Access Time—Main Memory—average	9.0 milsec	_____
High Speed Loops—average	1.7 milsec	_____
Arithmetic Speeds—Floating Point		
Add & subtract	.81 milsec (12 digits)	_____
Multiply	8.6 milsec (12 digits)	_____
Divide	8.9 milsec (12 digits)	_____

	RECOMP III	COMPETITIVE COMPUTER
Memory	Disk—Non-volatile	_____
	Capacity 4096 words	_____
	Word size 40 bits & sign	_____
	12 decimal digits	_____
	Command size—2 commands per word	_____
	Instruction capacity 8192 instructions	_____
Programming	Machine language (fixed point) very simple and versatile	_____
	Machine language (floating point) very simple and versatile	_____
Outputs—Standard	Typewriter (alphanumeric engineering keyboard)	_____
	10 char/sec (printing speed)	_____
	Paper Tape Punch	_____
	10 char/sec (punching speed)	_____
Outputs—Optional	Facitape High Speed Punch	_____
	150 char/sec	_____
	Up to four outputs	_____
Characteristics	250 pounds (computer)	_____
	Solid State	_____
	Desk size	_____
Power Requirements	3.5 amps any wall outlet 115 v ac	_____
Heat	No cooling needed	_____

If your computer, or a competitive computer, doesn't measure up to Recomp III, this coupon can save you time and money.

AUTONETICS INDUSTRIAL PRODUCTS
Dept. 45, 3400 E. 70th St. • Long Beach, California
Autonetics Division of North American Aviation, Inc.

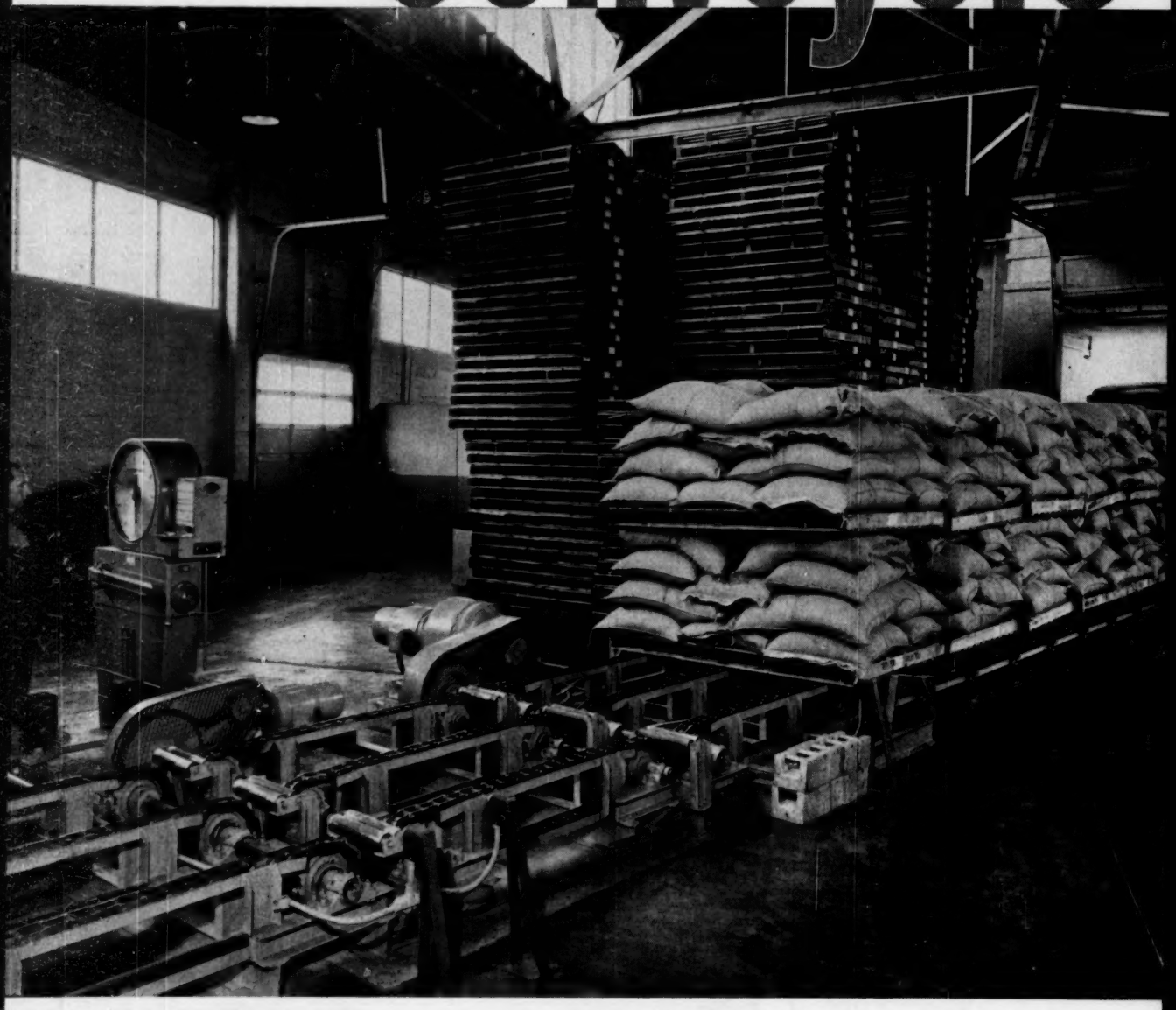
Please send me full information on the newest low-cost compact digital computer—Recomp III

Name_____
Position_____
Company_____
Address_____
City_____ **Zone**_____ **State**_____
Present Computer (if any)_____
Application_____

AUTONETICS Industrial Products

AUTONETICS DIVISION OF NORTH AMERICAN AVIATION, INC.

LINK-BELT conveyors



The last word in value from the first name in conveyors

CHAIN CONVEYORS—Carry the load directly on chain or drag bulk materials along a trough. Link-Belt builds a variety of chain conveyors with single or multiple strands . . . for light to extremely heavy-duty applications . . . for routes a few feet to hundreds of feet long. This conveyor unloads skids of bagged material from trucks, through weighing and to storage.

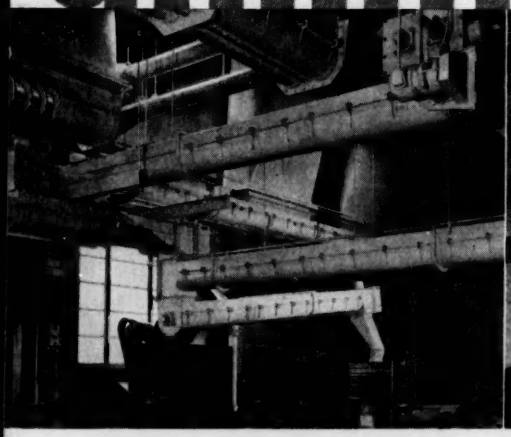
When it comes to your materials handling needs, it is a matter of sound economics to depend on Link-Belt, builders of industry's most complete conveyor line. In addition to this broad range of line, which permits unbiased recommendations, Link-Belt offers *quality*—achieved through engineering skills, manufacturing scope and research . . . *"experience unlimited"* in the materials handling field.

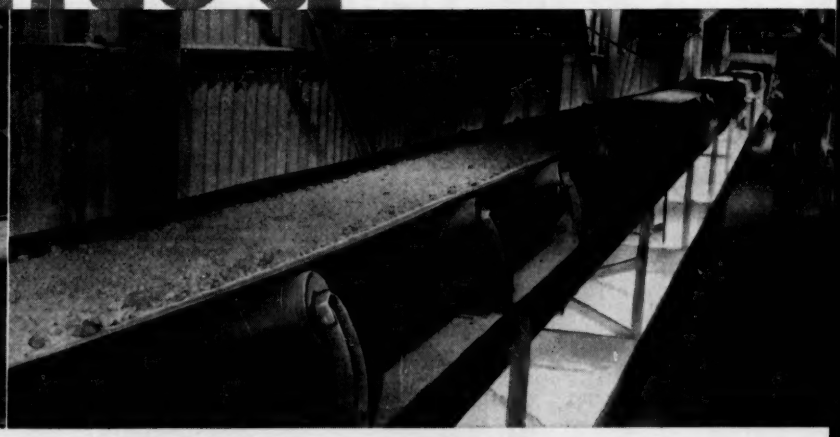
Also important, Link-Belt can provide *complete* handling systems . . . patterned exactly to your requirements with a background of more than 80 years of conveyor specialization. Our engineers are familiar with the particular handling needs of every industry. It's more than likely they have met—and solved—many problems similar to yours. We will design, equip and erect your entire installation . . . and accept full responsibility for its successful operation.

For full information—on single components or complete systems—large or small—contact your nearest Link-Belt office. Catalogs covering all conveyors are available on request.

unlimited

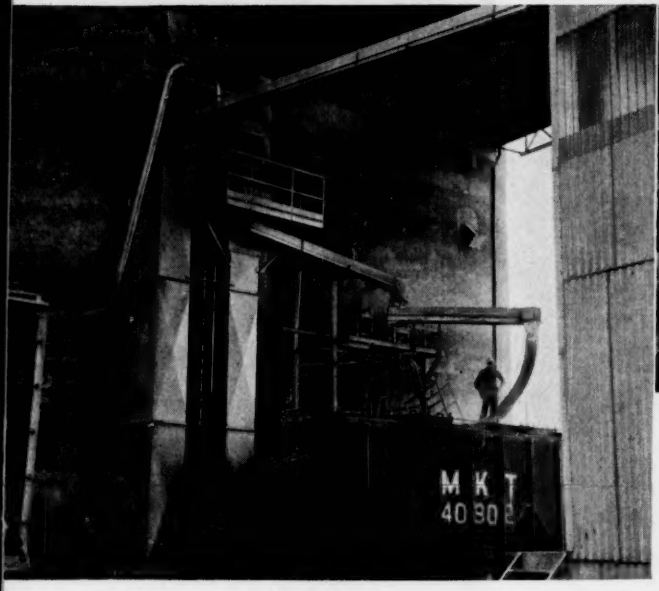
The line that means savings, whether handling parts or bulk materials, finished products or units

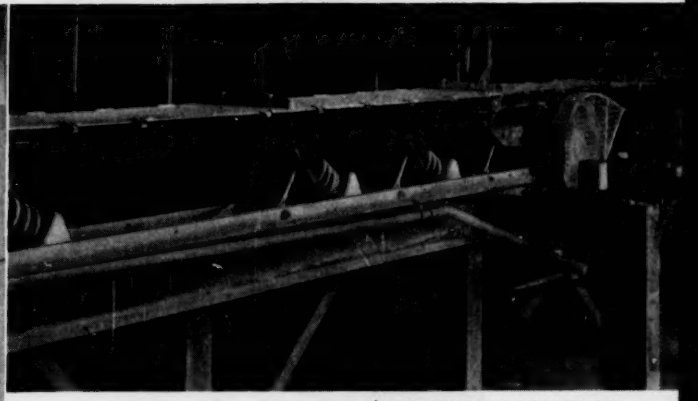




SCREW CONVEYORS—Easily adapted to congested locations . . . operate horizontally, vertically or inclined. Link-Belt provides all components for a complete screw conveyor line. Exclusive optional *Quik-Link* feature permits fast, easy removal of any conveyor section without disturbing other components.

BELT CONVEYORS—Link-Belt serves as a single source for design, equipment and erection of *Job-Engineered* belt conveyors for small or large tonnages, for routes of any length. Link-Belt engineers have the selection advantage of industry's most comprehensive idler line—plus a broad range of pulleys, drives, terminal machinery and auxiliary equipment. Husky, *Pre-Bilt* sectional belt conveyors are also available.





◀ **BUCKET ELEVATORS**—Unlimited solutions to vertical or inclined movement of a wide variety of materials—bulk or parts. Fourteen types in four basic designs are fabricated from Link-Belt designed and integrated components — factory aligned for low-cost installation, smooth performance.

▲ **OSCILLATING CONVEYORS**—Whether handling fines, granules or chunks, Link-Belt's four types of oscillating conveyors — Flexmount, Coilmount, Heavy-Duty Coilmount or Torqmount—provide surge-free movement of hot, wet or dry materials. All feature *full-time positive action*, yet operate as near to *natural frequency* as possible to minimize power requirements.

LINK-BELT

CONVEYING AND ELEVATING EQUIPMENT

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses and District Sales Offices in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs; Switzerland, Geneva. Representatives Throughout the World. 15,635

Keeping production on the move in every industry

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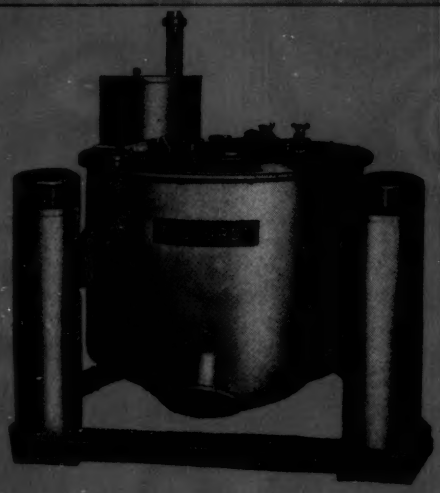
Arm and tray elevators
Belt conveyors
Bucket elevators
Bucket elevators-conveyors
Bulk-Flo
Car-type conveyors
Chain conveyors
Circular carrier conveyors
Drag conveyors
Flight conveyors
Flite-Flo conveyors
Oscillating conveyors
Power-and-free conveyors
Pusher chain conveyors
Scraper conveyors
Screw conveyors
Sidekar-Karrier conveyors
Skip hoists
Slat conveyors
Trolley conveyors
Trukveyors

liquid

SEPARATION

A TEAM OF SPECIALIZED MEN AND MACHINE
ECONOMICAL SOLUTION TO YOUR SPECIFIC



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BATCH-MASTER®
SUSPENDED
CENTER-SLUNG®
MAXI-FLEX®
CONTINUOUS

Niagara®

PRESSURE FILTERS

VERTICAL LEAF MODELS
in both horizontal and vertical tank designs, either fully automated stations or single filters.

BATCH-MISER®
horizontal plate models for polish filtration and batch operations

COMPLETE LABORATOR

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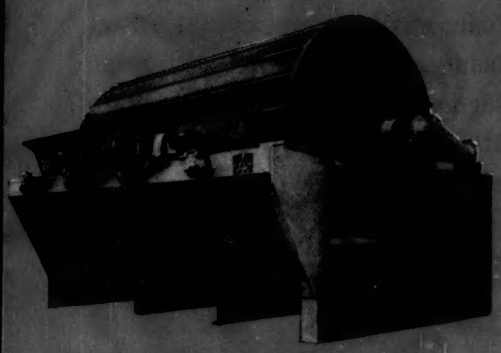
solids SPECIALISTS

specialists in LIQUID SOLIDS separation

Ex • Centrifugal Extraction • Pressure Leaf and Continuous Vacuum • Pressure Filtration • Filter Media

OFFERING THE MOST EFFICIENT AND
IQUID-SOLIDS SEPARATION PROBLEM



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CONTINUOUS FILTERS
CUSTOM ENGINEERED

VACUUM OR PRESSURE

ROTARY DRUM
Scraper, Precoat, String, Roller and Cloth Belt Cake Removal

HORIZONTAL TABLE

DISC

FEON®

NATURAL AND MAN-MADE FILTER MEDIA

FEON manufactures correctly designed

- Anode bags and diaphragms
- Centrifugal liners
- Dust tubes
- Plate and frame filter covers
- Pressure leaf discs
- Pressure leaf sacks
- Vacuum disc sector bags
- Vacuum drum covers, belts, blankets
- Yardage produced or slit to width

TESTING FACILITIES AVAILABLE

WRITE FOR LITERATURE. PLEASE SPECIFY: TOLHURST . . . NIAGARA . . . FEINC . . . FEON

DIVISIONS OF
American Machine and Metals, Inc.
EAST MOLINE, ILLINOIS

Now... a low-temperature insulation with half the K-factor

RIGID URETHANE FOAM

This superior new industrial insulation made with Du Pont HYLENE® organic isocyanates utilizes a blowing agent of Du Pont FREON® fluorocarbon to bring you a combination of properties and advantages never before possible. Not only is urethane foam easier to apply, it actually has double the insulating capacity of ordinary insulation because its K-factor is *half* that of conventional materials. Result: significant reductions in installation and maintenance costs, as well as more effective insulation. Check the advantages below and see how *you* can benefit by using this versatile new urethane foam insulation:

• **Twice the insulation value of conventional materials.** Excellent K-factor (.12-.14, compared with .26-.28 for ordinary insulation) because low conductivity FREON remains entrapped within foam cells.

• **Simplified, low-cost installation.** Can be foamed in place by pouring into cavity as a liquid. Foam expands and hardens, filling every corner and crevice without seams or leaks. Ideal for complex contours, irregular voids. Large surfaces can be sprayed. Pre-molded foams eliminate field cutting. Also available in slab or block form.

• **Excellent resistance to deterioration.** Retains its rigid, cellular form without crumbling. Proven resistance to chemicals (including benzene, toluene, carbon tetrachloride) and to gasoline, motor oil, moisture, natural aging. Foam can be formulated to burn slowly in presence of flame; extinguish itself immediately when flame is removed.

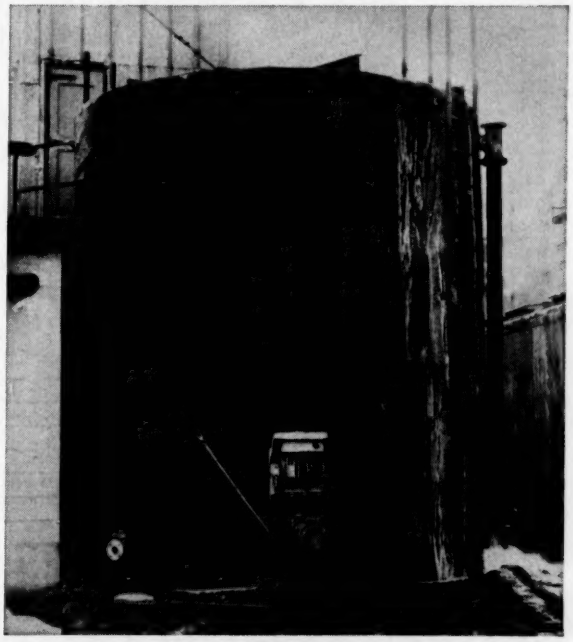
of conventional materials, new ease of application

MADE WITH DU PONT HYLENE®

Rigid urethane foam made with Du Pont HYLENE also adheres well to metal, wood, glass, fabric, most other materials. Bond strengths often are equal to strength of foam itself. It possesses good vibration and sound dampening properties. Closed cell structure prevents moisture absorption that drastically reduces insulating properties of ordinary materials.

Already these versatile new urethane foams are filling a number of insulating needs. Among them: *cold storage rooms and doors, refrigerated railroad cars and trucks*—where light weight and high insulating capacity are important; *piping and equipment, ceilings, floors and walls, duct work and roof decking*—where ease of application and resistance to deterioration are required.

Naturally, properties and advantages of urethane foams vary according to their formulations and intended uses. Specific needs should be discussed with your foam supplier. For more detailed information and a list of rigid urethane foam suppliers, write today to: E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Department CE-5, Wilmington 98, Delaware.



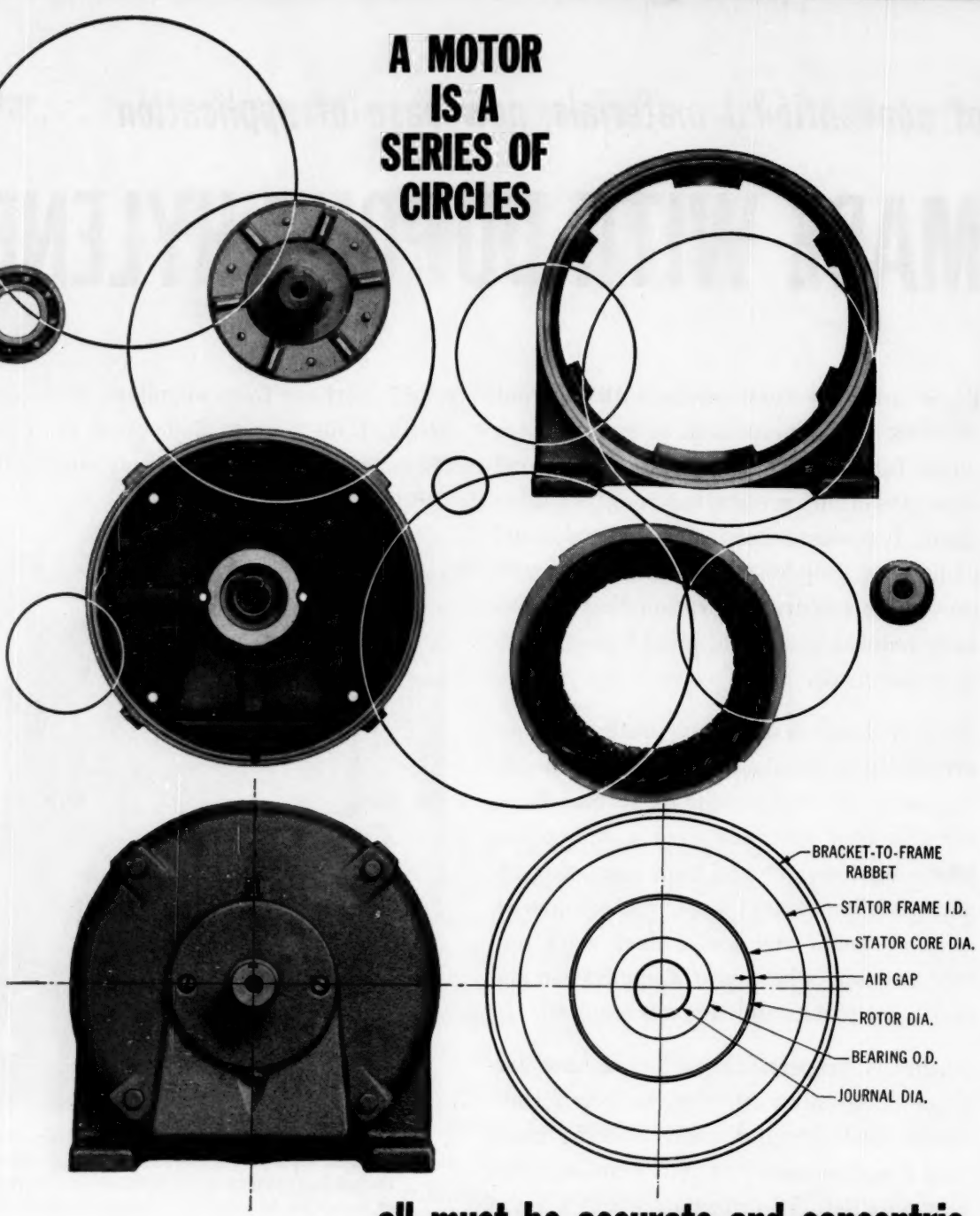
Inch-thick layer of urethane foam insulation with asphaltic vapor barrier, sprayed on soda ash make-up tank in a chemical plant, is now in its third year of resistance to moisture, corrosive atmosphere.

DU PONT
REG. U. S. PAT. OFF.

HYLENE®
FOR URETHANE FOAM INSULATION

Better Things for Better Living . . . *through Chemistry*

A MOTOR IS A SERIES OF CIRCLES



all must be accurate and concentric

In manufacturing Elliott Crocker-Wheeler motors, a dozen critical "circles" are formed accurately and concentrically through unique and extraordinarily precise production methods. The result is exact alignment of all parts, true and uniform air gap, free-spinning rotor, quiet, cool, dependable operation.

■ *Elliott Crocker-Wheeler integral-hp a-c and d-c motors—from smallest to largest—are offered in all conventional enclosures and modifications; with insulation to suit the application, including* EPASEAL *epoxy insulation for use where conditions are most severe.*

W1-3

ELLIOTT COMPANY

GENERAL OFFICES: JEANNETTE, PENNSYLVANIA

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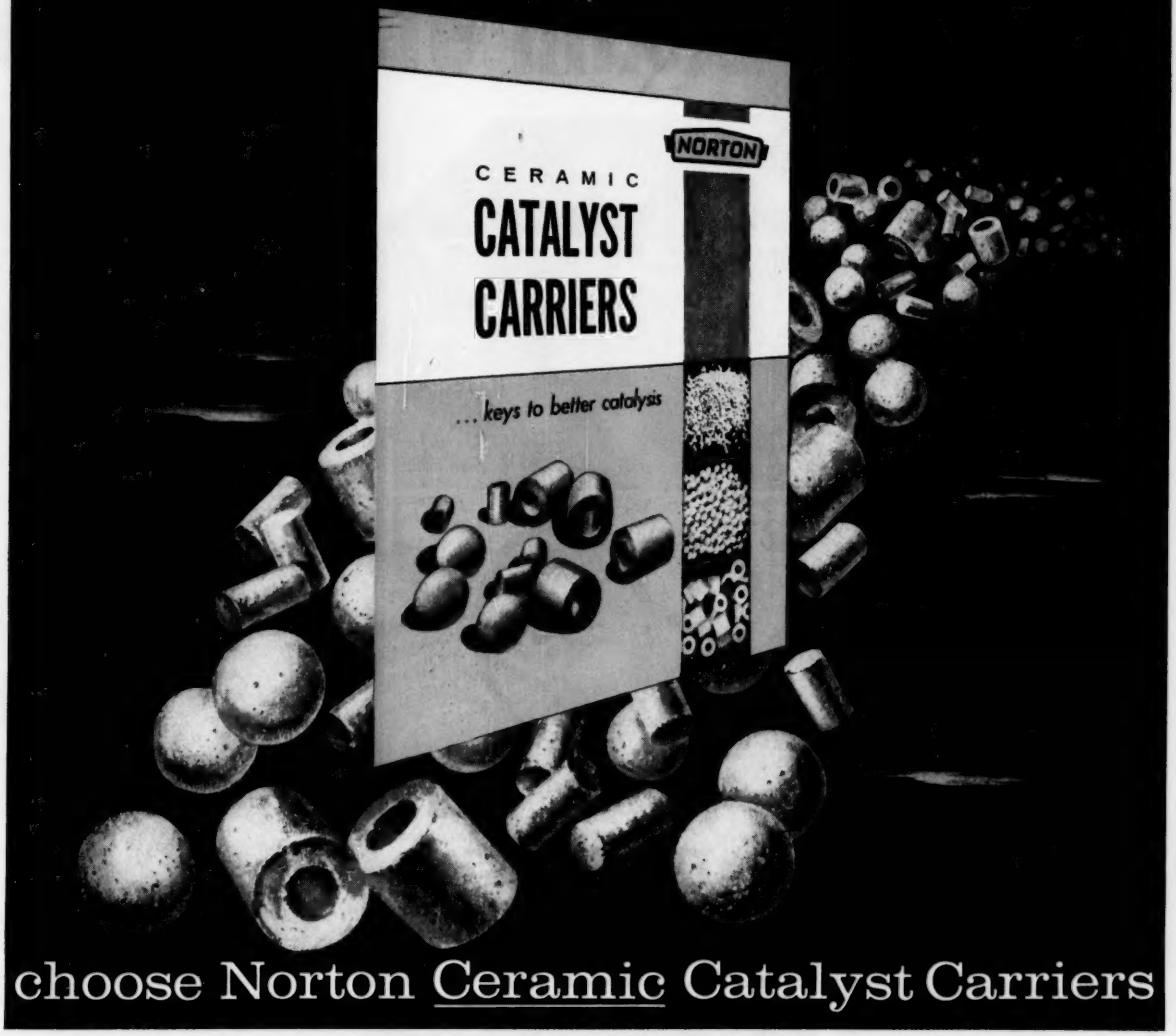

choose Norton Ceramic Catalyst Carriers

In reactor columns throughout the chemical and petrochemical industries, Norton Ceramic Catalyst Carriers are helping improve catalyst life, lower catalyst costs, and provide optimum yields from reactions.

It's *consistent* high performance, too, because every Norton carrier in any quantity is uniform from lot to lot. Size, porosity, and purity are held to close tolerances. Duplication of specifications is assured.

Today, probably the most widely-used Norton carrier is alumina. ALUNDUM* alumina carriers are available as spheres, pellets, rings, granules and powder. However, as new processes are developed, and more demanding physical, chemical and thermal conditions are encountered, new Norton carriers are ready to meet catalyst specifications. Various new materials and shapes are now available in alumina, silica, zircon, zirconia and silicon carbide. These Norton developments offer porosities ranging from 8% to 65% and surface areas from less than 1 to 70m^2/gram (BET method).

Why not contact your Norton Man? Through him you can draw upon the wealth of Norton research and engineering data compiled over the years. He is well qualified to help you meet catalyst carrier specifications exactly . . . efficiently . . . economically. Your requirements for new and unusual carriers will receive our prompt attention.

Norton carriers are described in detail in the Bulletin, "Keys to Better Catalysis." For your copy, or for technical assistance, write NORTON COMPANY, Refractories Division, 504 New Bond Street, Worcester 6, Mass.

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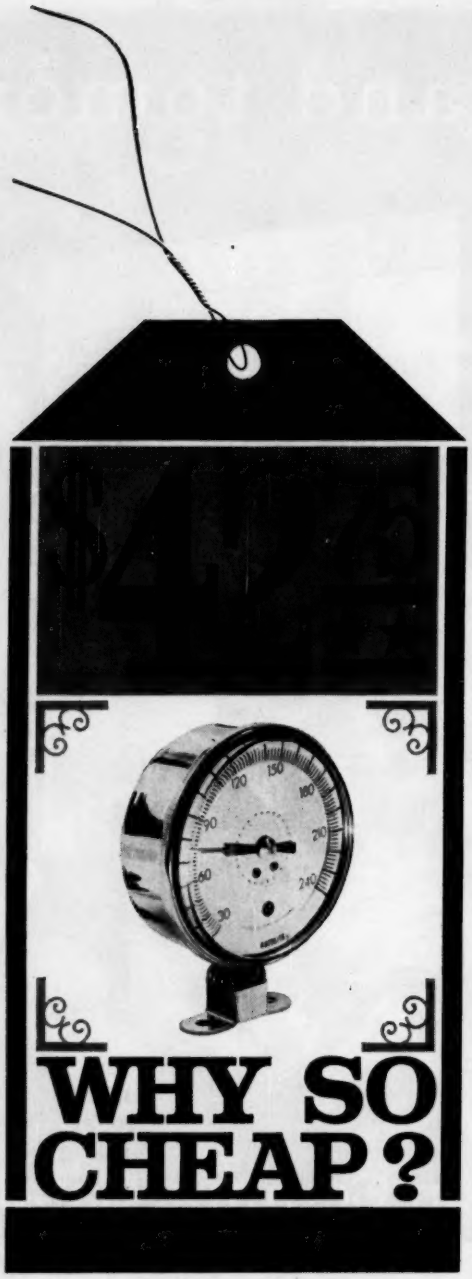


WHY SO CHEAP?

A lot of people (whom we'd like to have as customers) look twice when they see the prices on our new liquid-filled dial indicating thermometers. We don't blame them. They're used to paying 200% more. Our prices are shockingly low. How do we do it? Simple!

We have designed a clever universal mount. One mount satisfies many installation problems (reduces production and stocking costs and allows lower prices to you). We save on the unique but rugged outer casings, too. (So you save even more). But corner cutting ends here. These devices are devils for durability. Built tough to take it. Dials are big, legible, raised to reduce parallax reading error. They are sidelighted to provide better illumination. Inside? Strictly precision. The mechanisms; solid liquid-filled Bourdon tubes, are made and calibrated completely by hand (ever so carefully) just to insure reliability, accuracy, and long life.

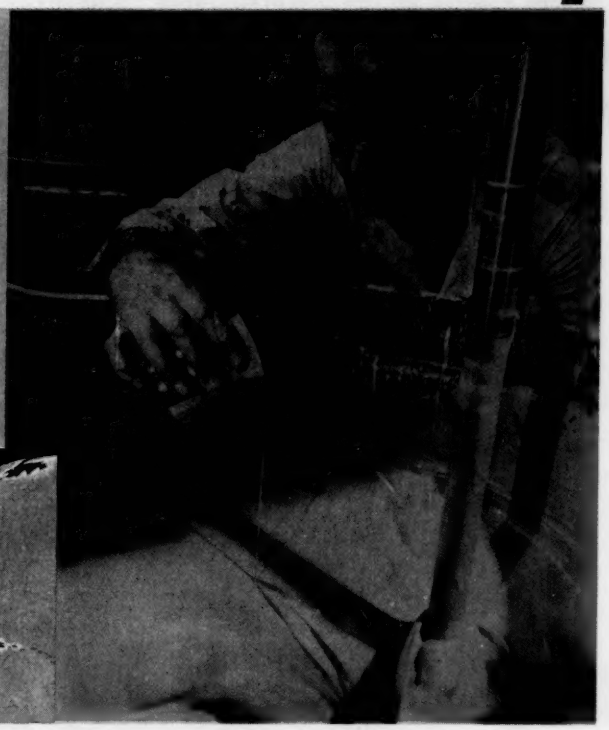
They are direct acting... no gears or cams to wear or fail. We guarantee every one to meet full industry specifications. So look twice at the price if you like, but look twice at the instrument, too. It is just one of a complete line of Autolite instruments that will change your opinion on how much quality costs in today's market. Another reason why you're always right with Autolite.

AUTOLITE

INDUSTRIAL INSTRUMENT DIV. • PORT HURON, MICHIGAN

6,000,000 yards of trim color paste mixed annually

Cowles Dissolvers produce enough to border the highway from San Diego to Bangor for Ford Motor Company



More than six million yards—18 million feet—3400 miles—of vinyl coated plastic automotive trim material are manufactured by the Ford Motor Company annually. To color this material over 30 different colored pastes must be mixed—quickly, uniformly, economically.

For this purpose Cowles Dissolvers are used. You probably will never need to mix color pastes for trim materials to line the highway between the extreme corners of the country. But the same advantages of big-volume production, in very small space, at minimum cost that accrue to Ford are characteristics of Cowles results on hundreds of products.

Typical ones include—**Adhesives, Ceramic slips, Chemicals, Foods, Inks, Paints, Plastics**... in fact, any product requiring mixing, dissolving, dispersing, emulsifying or deagglomerating. Extremely versatile, Cowles Dissolvers are applicable to processing of solid-liquid, liquid-liquid and gas-liquid materials. Viscosities up to 50,000 centipoises or more are easily handled.

The patented impeller, with "teeth that make the big difference," and the exclusive MPD* (Maximum Power Delivery) drive that gives you plenty of power even at slowest speeds assure you big volume and high quality at low cost. It will pay you to investigate. Write today for complete details.

*Reg. T.M. of The Cowles Dissolver Co., Inc.

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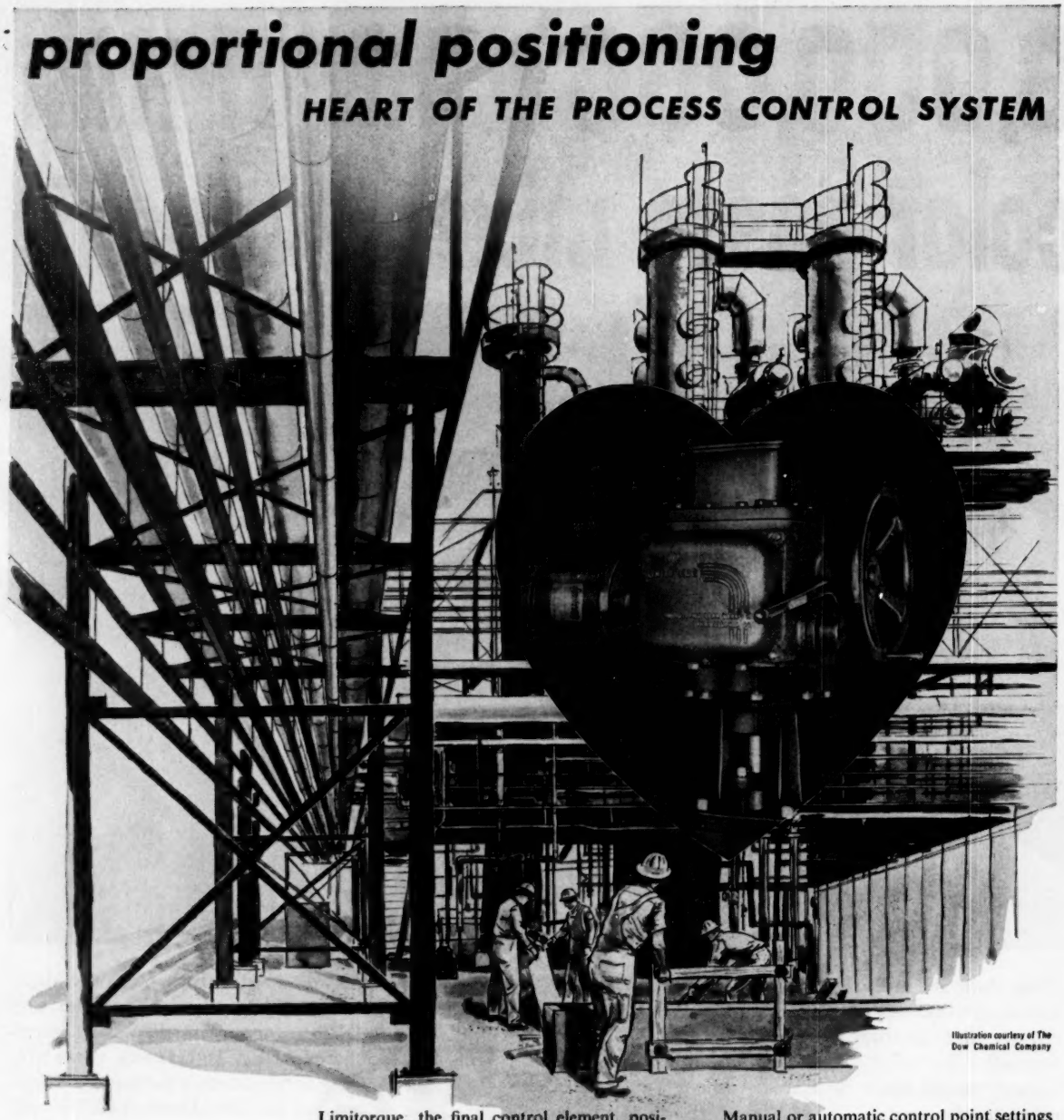

Illustration courtesy of The Dow Chemical Company

LimiTorque converts any variable into a constant...

Limitorque, the final control element, positively converts any up-stream process variable into a down-stream constant by continuously repositioning the control valve.

LimiTorque can be adapted to any control signal given by existing process control equipment and transducers.

Complete control systems are available from LimiTorque, and the components employed in the systems are chosen for dependability, with the elimination of complex circuits and special power supplies, and ease of maintenance.

Manual or automatic control point settings may be made in the control instruments of these systems and thus the required final control position is assured in proportional relationship to variations in the measured conditions.

The demand for centralization of performance responsibility in a single source, for complete process control system, is more than adequately met by these modern all electric actuator systems.

For more detailed information, write for Bulletin #6-57.

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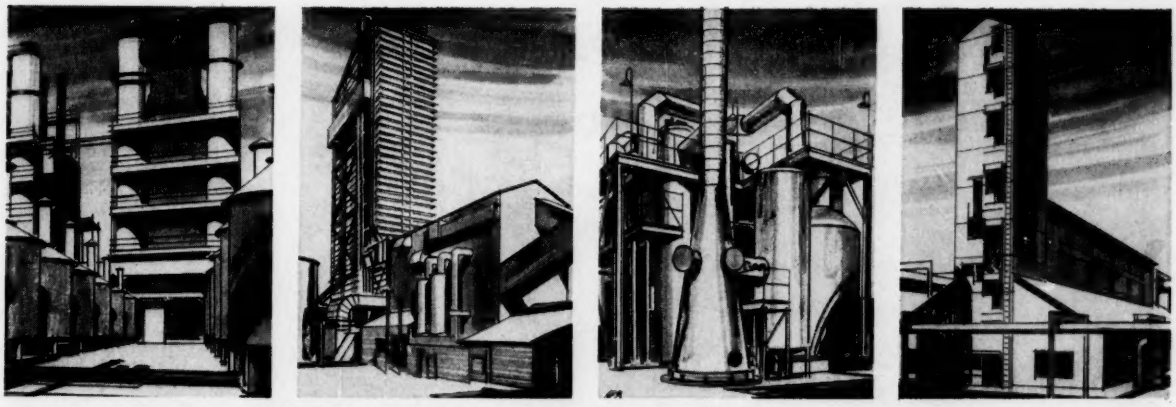

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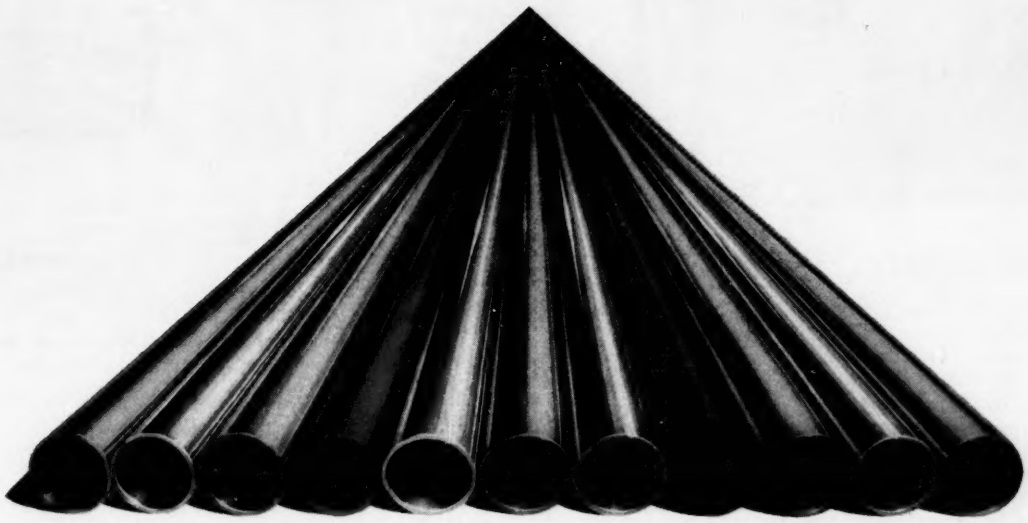
PHELPS DODGE COPPER-BASE ALLOY TUBES have a reputation for reliable "On-Stream" Performance!



■ Wide line of finest quality copper-base alloys for every kind of application need—including bi-metal combinations.

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■ Expert engineers to help you solve tube corrosion problems, select the exactly correct alloy for your applications.

Specify the best—at the same cost as the rest!

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PD

GLC Anodes Are CUSTOM MADE

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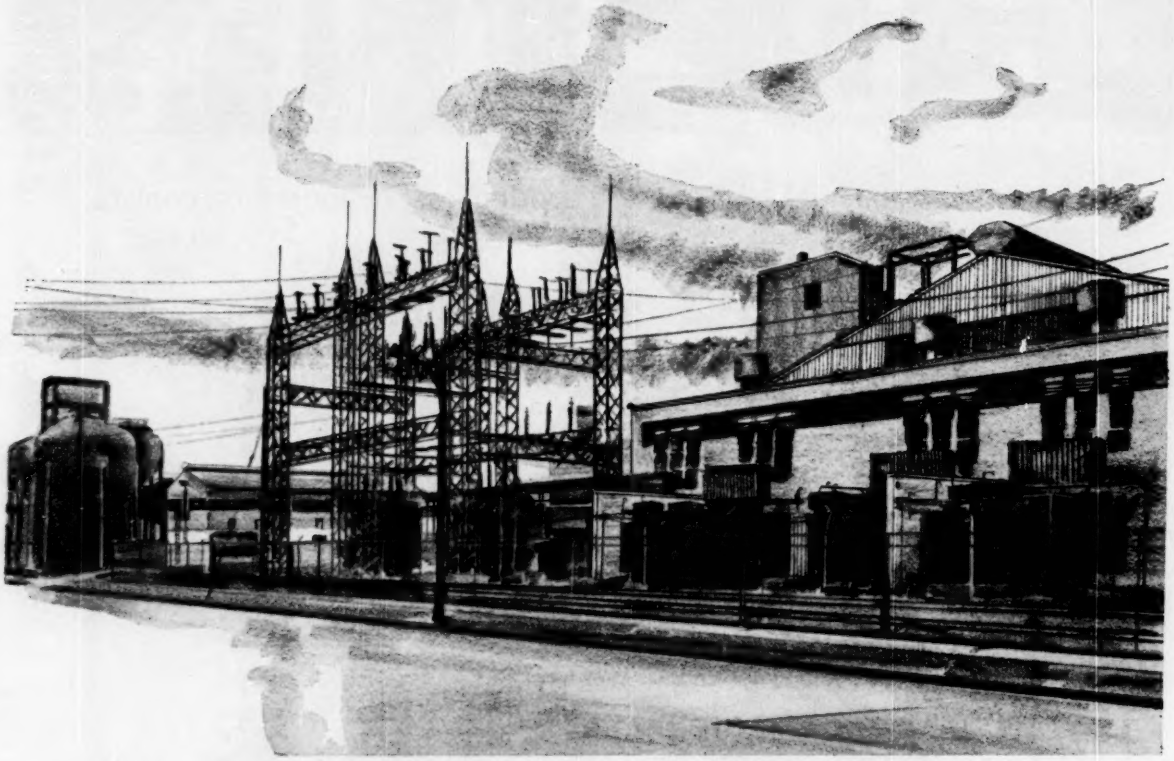

The Olin Mathieson Chlor-Alkali Plant at Niagara Falls, New York

TECHNICAL TEAMWORK with our chlor-alkali customers provides a base for continuing improvements in GLC anode performance. Our program of progress gives GLC anode customers better results now than ever before —seeks still better results in the years ahead.

SHARE THE REWARDS of this program by putting custom made GLC anodes to work now in your electrolytic cells. We can then help you develop the technical information and specifications needed to improve cell efficiency and lower your operating costs.

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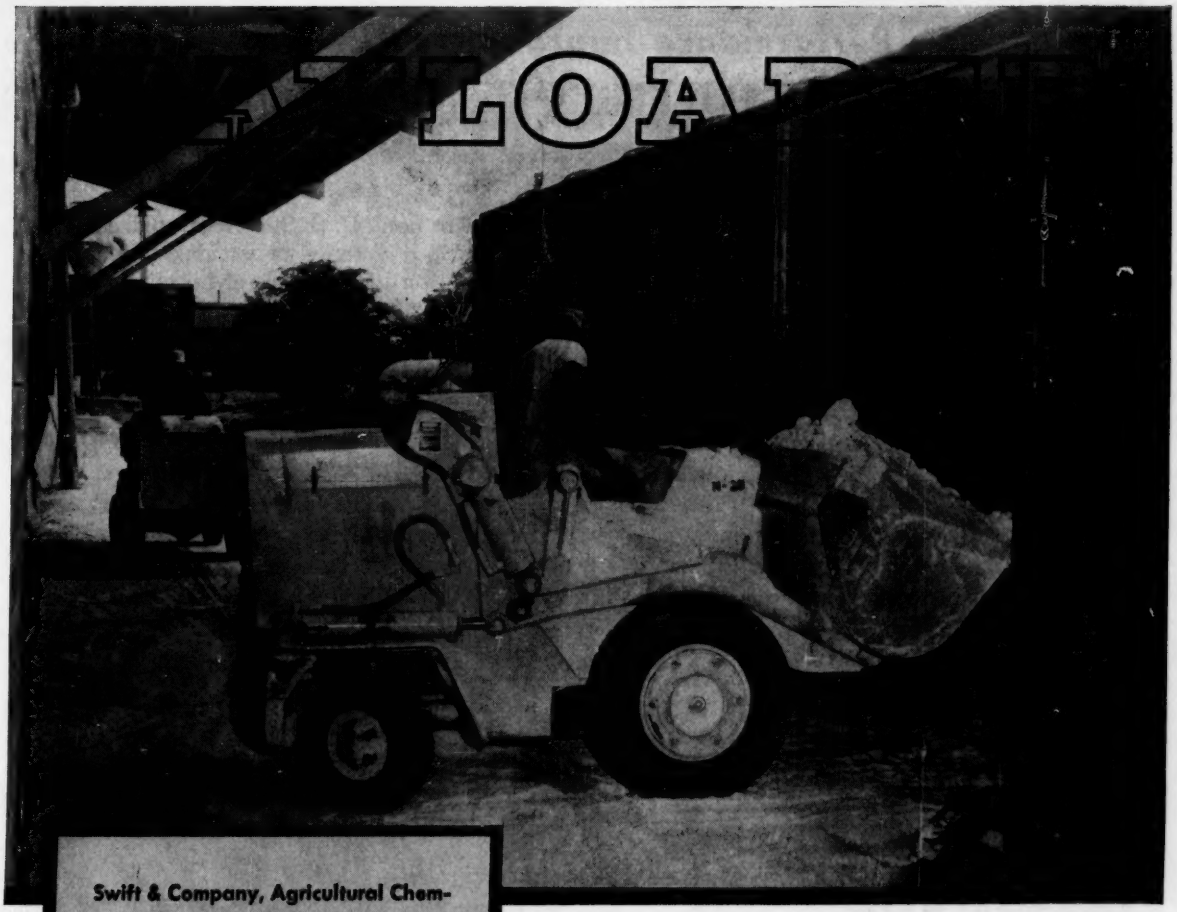

Swift & Company, Agricultural Chemical Division, is one of the oldest and largest of fertilizer manufacturers. It was one of the first chemical companies to use integral-design tractor-shovels as pioneered by The Frank G. Hough Co. some 20 years ago, and has purchased several hundred of these PAYLOADER units. Moreover, the advice, counsel and criticism from Swift personnel have contributed much to the continual improvement of PAYLOADER designs through the years — a fact that the Hough organization appreciates and is glad to acknowledge.

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THE FRANK G. HOUGH CO.
LIBERTYVILLE, ILLINOIS
SUBSIDIARY — INTERNATIONAL HARVESTER COMPANY

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Production Protection

Superintendents of fertilizer plants will agree that "dependability" is an important, if not the chief, consideration when they buy mechanical equipment. A mechanical failure anywhere along the line, especially during night-and-day peak-season operations, can be a serious and costly interruption.

Hough engineers know this too, and have designed more production-protection into the Model H-25 PAYLOADER than has ever before been provided in a tractor-shovel. As one plant superintendent testifies, "The maintenance on our two H-25's has been lower than on any loader previously used."

Extraordinary Protection includes two-stage dry-type air cleaner system; cartridge-type oil filters on all three oil systems; sealed, self-adjusting hydraulic service brakes; parking brake enclosed in transmission; special grease and oil seals on all vital points.

Your Hough Distributor will be glad to show you how the H-25's greater-production and lower-maintenance can help "ease the profit squeeze" of your bulk handling.

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Packed Tower Performance Improved with

"GAS-INJECTION" SUPPORT PLATES

The dramatically lower pressure drops expected through the higher bed voidage obtainable with Intalox® Saddles and Pall Rings cannot be realized when the packing support plate restricts gas and liquid flow.

For maximum performance from these newer packings, the support plate must provide an effective free area equal or greater to the free area of the bed (which in some instances may run as high as 95%).

To meet this need, U. S. Stoneware engineers have developed a series of packing support plates based on the principle of injecting the gas into the bed above the point where the liquid disengages. Thus, liquid leaving the column cannot restrict gas flow into the column and the low pressure drops anticipated from Intalox Saddles and Pall Rings can be fully realized.

"Gas-Injection" Support Plates* are made in a variety of types and from a number of materials.

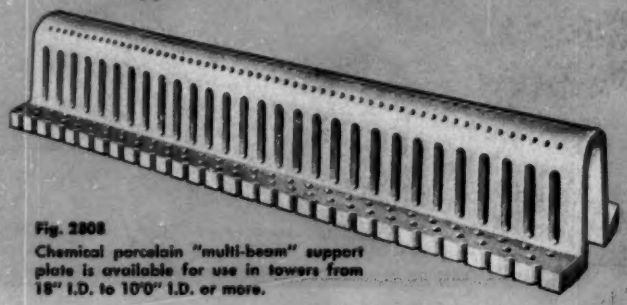


Fig. 2808
Chemical porcelain "multi-beam" support plate is available for use in towers from 18" I.D. to 10'0" I.D. or more.

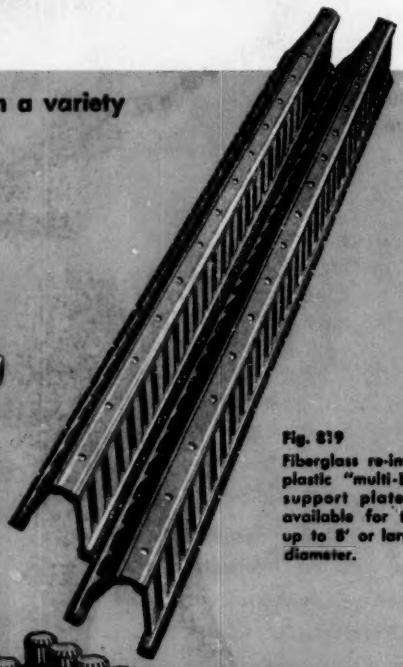


Fig. 819
Fiberglass re-inforced plastic "multi-beam" support plates are available for towers up to 8' or larger in diameter.

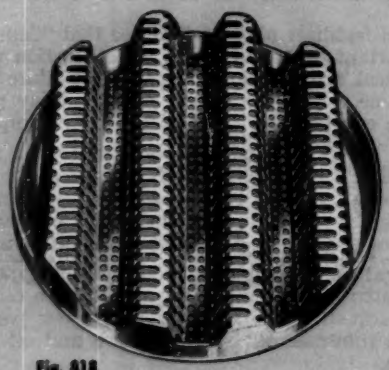


Fig. 818
The "gas-injection" principle is available in any of the weldable alloys or elements in one-piece or two-piece construction for towers 12" through 48" or in multi-beam construction for towers of unlimited size.

(Carbon plate)
Support plates incorporating the "gas-injection" principle are likewise available made from impervious graphite.

*Covered by patents granted or pending.

WRITE FOR THIS NEW BULLETIN

Bulletin TA-40 gives full technical data on "gas-injection" support plates, plus U. S. Stoneware's line of distributors and hold-down plates. Free on request. Write Process Equipment Division.

433-G

Process Equipment Division

U. S. STONEWARE

AKRON 9, OHIO

Top news stories and what they mean to CPI technical decision-makers

Chementator

Fluid catalytic cracker set for closed-loop computer control

Petroleum refiners, with their high-throughput units, are evidently having an easier time than most chemical processors justifying expensive digital computers for control applications.

Case in point: Standard Oil of California will have the 40,000-bbl./day catalytic cracker at its El Segundo, Calif., refinery under computer control early this summer. And it expects the computer to pay for itself: an increase of only 2% in the value of the cat cracker's output will provide an adequate payout for the custom-built IBM equipment. (Several other computer-control installations have partly been written off to research and development.)

Standard's computer will monitor 75 variables on the unit, then utilize its linear program to calculate proper controller settings for optimum product mix every 15-20 min. System is designed for open or closed-loop control. As operators become familiar with the equipment, they can instruct the computer to reset most of the important variables automatically.

Another, as yet unidentified, petroleum refining unit is also slated for computer control. Universal Oil Products, working with Daystrom, Inc., expects to start up a computer-run unit sometime this year.

Alkaline extraction process may yield new source of polyesters

The Institute of Paper Chemistry, Appleton, Wis., has been granted a patent (U. S. 2,983,724) for the extraction of para-hydroxybenzoic acid (PHBA) from cabbage palmetto and other palm trees.

Though strictly in the lab stage now, this development could be of great interest to polyester resin makers. Several patents have been granted for producing polyesters from PHBA, but its current $1/lb. price tag has prevented any commercial application. The Institute's new process is quite simple, however, and could probably turn out PHBA at a fraction of its present price.

Only firm now producing this material is Heyden Newport, which probably uses the standard phenol carboxylization route. An isomer of salicylic (ortho-hydroxybenzoic) acid, PHBA now is used mainly in pharmaceuticals, glues and dyestuffs.

The process, developed by the Institute's I. A. Pearl, consists of alkaline hydrolysis of the palm wood, followed by acidification of the extract and then solvent extraction of the PHBA (ether was used in the lab). Yields of the acid run 40-50% of the extractive part of the wood.

The cabbage palmetto, which has the highest known concentration of PHBA, grows profusely in the Southeast; pulpers in Florida have to clear it in order to get at the more desirable woods. Since the palmetto makes a satisfactory corrugated medium, liner, and other low-strength fillers, it is possible that mills could pulp this weed tree and produce PHBA as a profitable byproduct.

The Institute's process will be available for licensing to its member companies and to "other interested parties."

Preheating oxygen-methane mixture gives higher acetylene yields

Another partial-oxidation process for producing acetylene from gaseous hydrocarbons is now available for licensing. Hydrocarbon Research, New York, is teaming with Delhi-Taylor Oil Corp. to offer a process achieving 15% higher yields than other partial-oxidation routes to acetylene.

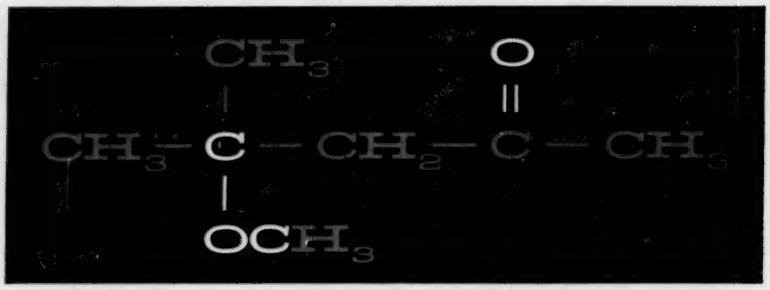
Key to the higher yields is premixing of the oxygen and methane (or other hydrocarbon), allowing the mixture to be heated to 1,500 F. or higher before oxidation. Other processes heat the gases separately, only go as high as 1,200 F. during preheat. Thus, the HRI-developed burner consumes less of the hydrocarbon

BULLETIN:

Comparative data on Shell Chemical's high boiling Pent-Oxone* solvent promises lower costs on vinyl lacquers

Pent-Oxone solvent is a keto-ether. It is a remarkable new compound of this class of chemical which gives you double solvent action plus high diluent tolerance for use with a wide range of lacquer resins.

Read how Pent-Oxone solvent compares with other high boiling vinyl solvents in evaporation and viscosity, what it costs, and where it is finding new applications in and out of the coatings industry.



Solvent action in glycol ethers comes from the COC ether linkage. In ketones, the double bond oxygen does the work. Shell Chemical's Pent-Oxone is the only commercially available solvent with *both* these functional groups.

BECAUSE it combines the solvent properties of ketones and glycol ethers in one molecule, Shell Chemical's new Pent-Oxone gives you greater solvent potential than any other type of high boiler.

This potential can often save you money. In vinyl lacquers, Pent-Oxone can replace high boilers costing 40¢ to $1.10 more per gallon.

Comparative evaporation data

Pent-Oxone is in the high boiling class with an evaporation rate comparable to cyclohexanone and EGMEE acetate. Comparisons with cyclohexanone and isophorone in seconds are as follows:

Per Cent evap.	cyclo-hexanone	Pent-Oxone	iso-phorone
10%	180	231	2600
30	560	715	8300
50	940	1200	14200
70	1330	1680	20600
90	1720	2175	27600
95	1825	2310	29500
100	2120	2450	34000

Comparative viscosity data

The following viscosity comparisons are taken after one hour on a 50/50 solvent/toluene mixture with the indicated Vinylite** resin:

10% VYNS-3	Pent-Oxone	93 cps.
	cyclohexanone	54 cps.
20% VMCH	Pent-Oxone	125 cps.
	cyclohexanone	142 cps.
	isophorone	260 cps.
20% VYHH	Pent-Oxone	310 cps.
	cyclohexanone	232 cps.
	isophorone	285 cps.
20% VAGH	Pent-Oxone	500 cps.
	cyclohexanone	320 cps.
	isophorone	405 cps.

With VAGH/Pent-Oxone solvent, viscosities rise with time. This can be overcome by using 50/50 Pent-Oxone solvent/cyclohexanone as the active solvent. Such a mixture would save you 55¢ per gallon against using cyclohexanone alone.

Better odor, lower cost, many uses

The price of Pent-Oxone is 17.5¢ per pound delivered in tank cars. It can tolerate up to 70% diluent in vinyl chloride/vinyl acetate copolymer solutions. It has a better odor than other vinyl solvents and is proving valuable in vinyl adhesives as well as acrylic lacquer thinners.

In nitrocellulose lacquers, Pent-Oxone retards blush, dries in reasonable time. It acts as a coupling agent in sludge removing compounds.

Complete data and samples

For samples and information, including complete graphs on viscosity and evaporation, write or call any of Shell's 9 Industrial Chemicals Division offices, or write Shell Chemical Co., 110 W. 51 St., New York 20, N.Y.

Do it today. Start investigating Pent-Oxone's remarkable keto-ether action for yourself.

*Trade mark, Shell Chemical Company
**Trade mark, Union Carbide Corp.

A Bulletin from

Shell Chemical Company

SHELL

Industrial Chemicals Division

and O_2 to sustain the 2,700 F. reaction temperature.

For production of 100 tons/day acetylene, the new route would need 400 tons/day oxygen and 16.3 million cu. ft./day natural gas. This is about 15% less raw material than other processes need, saving an estimated 0.5¢/lb. in acetylene production costs.

Hydrocarbon Research has proved its burner design in a 5-ton/day pilot plant at South Charleston, W. Va. Among the mechanical features of the stainless steel burner are a sintered Alundum flame arrester to prevent flashback from the burner to the preheater, and a water-cooled burner wall that eliminates carbon-formation problems.

Effluent from the burner contains about 9½ wt. % acetylene that must then be concentrated. Delhi-Taylor, which has developed some novel twists for tail-gas cleanup, will contribute the purification system to its joint project with HRI.

First plant to use the Fluor process (see p. 50) for bulk removal of H_2S from natural gas will be constructed near Bremen, West Germany, for Wintershall. A. G. Plant will treat 28 million cu. ft./day at 1,000 psi., employing the same propylene carbonate solvent used to remove CO_2 at El Paso Natural Gas Co.'s Terrell County, Tex., installation.

Adsorption process provides paraffins for chemical synthesis

Recent pilot-plant data have shown that molecular-sieve adsorption can provide pure straight-chain hydrocarbons in the C_{10}-C_{22} range, reports Universal Oil Products. In a paper given by D. B. Broughton and A. G. Lickus at the recent American Petroleum Institute meeting in Houston, UOP revealed that its Molex adsorption process has been extended from gasolines up to hydrorefined stocks in the kerosene and light gas-oil range (630 F. ASTM end point).

Straight-chain paraffin extract can be fractionated into concentrates over 95% pure. Availability of pure paraffins opens up new possibilities in chemical synthesis, eg., chlorination to make flameproofing agents, plasticizers and lube oil additives.

An especially promising possibility is in the use of these straight chains to make detergents that could be attacked by biological sewage treatment. Present detergents, which contain branch-chain hydrocarbons, are resistant to biological attack and are creating foam problems in many sewage plants and streams. (Continental Oil has this same detergent market in mind for the straight-chain alcohols that it will soon be producing from its new plant at Lake Charles, La.)

A Molex unit to produce 850 bbl./day of C_{10}-C_{22} paraffins from 4,350 bbl./day kerosene or gas-oil containing 23% straight-chain material would cost about $2.5 million, including sieves. Operating costs are estimated at 0.58¢ lb. normal paraffins.

Host of new petrochemicals come from controlled oxidation process

By using a rain of finely divided solids to control reaction temperatures, an entirely new phase of hydrocarbon chemistry is opening up. This is the opinion of M. R. Fenske, Pennsylvania State University, expressed in a paper given before a recent AIChE symposium in Newark, N. J.

To provide close control of highly exothermic oxidation reactions, Fenske employs a cylindrical reactor in which particles of an inert solid, such as fused alumina, shower down through the rising hydrocarbon vapor. Reactor used in pilot studies is 2 ft. high and 1½ in. in dia., made from carbon steel. Oxygen is injected at several points along the height of the reactor.

Fenske describes the unit as a "free-radical factory," causing many seemingly implausible reactions to occur at high yield. Generally, at lower temperatures (750 F.), bulk of the products are oxygenated compounds. At higher temperatures (1,000 F.), olefins are produced. Total hydrocarbon conversion ranges from 30-70%.

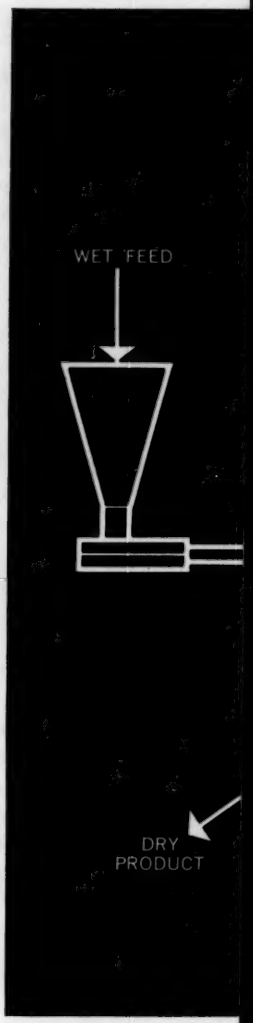
Among the products that are obtained in good yield from a wide range of paraffin and olefin feeds are aldehydes, epoxides and glycols. A 2-butene feed, for example, at 775 F. and 1 atm. pressure, produces a total hydrocarbon conversion of 32%, with acetaldehyde making up 34% of the product. Many complex ring compounds are also produced, some of which have

(Continued on page 38)

AN EFFICIENT NEW TECHNIQUE FOR

Another development of the versatile

DORRCO® FLUOSOLIDS® SYSTEM



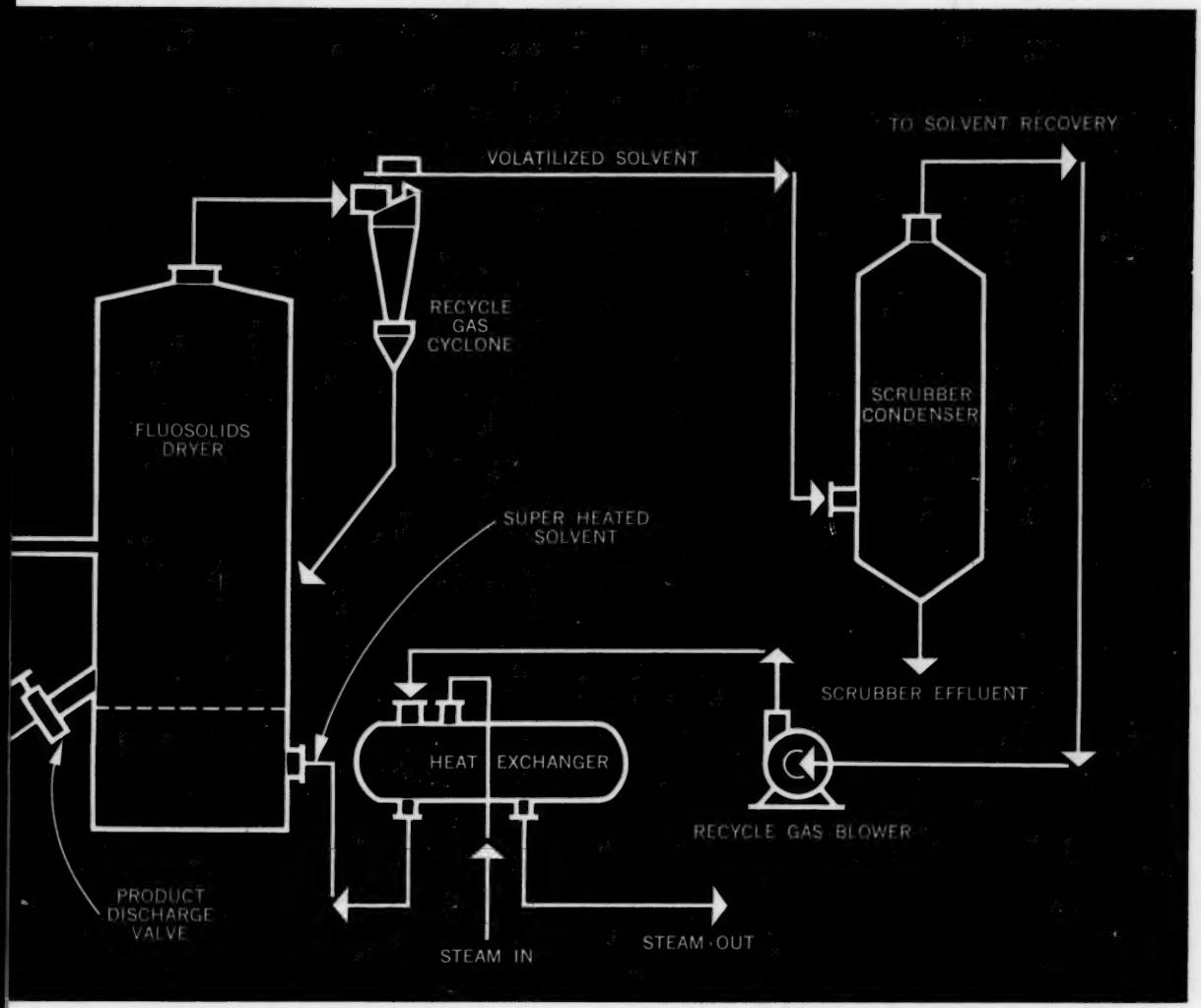
Application of the Dorrco FluoSolids System to the drying of heat-sensitive materials containing recoverable volatile solvents brings a new and highly efficient technique to the plastics industry. Typical materials that can be handled include polyvinyl chloride, polystyrene, polycarbonates, polyethylene, polypropylene, and polyvinyl alcohol.

Drying is accomplished in a fluid bed where the solvents are volatilized. Heat is provided by superheating the solvent and recycling it to the fluid bed. No separate gas generator is required. The system provides for complete recovery of the valuable constituents contained in the feed with the minimum of equipment. Ease of sealing against loss of solvent is a special feature. With no moving parts, seals are not required. Product cannot be contaminated by sealing compounds.

Outstanding advantages are the efficient and easily controlled drying conditions obtainable with the FluoSolids technique, low space requirements, low maintenance and minimum need for labor. Start up and shut down is fast and safe. Instrumentation is easily applied for automatic operation. Power and heat requirements are low.

Proof of successful operation has already been provided in an important installation which is now onstream. Design capacity was reached almost immediately, with a minimum of operational difficulties. Valuable experience accumulated by Dorr-Oliver engineers offers an effective basis for future recommendations. For information and estimates on complete drying systems engineered to meet your particular conditions, write to Dorr-Oliver Incorporated, Stamford, Connecticut.

DRYING HEAT-SENSITIVE PLASTICS



FLOWSHEET OF TYPICAL INSTALLATION

Wet feed is supplied continuously from bin by screw feeder to the FluoSolids Dryer, where preheated recycled solvent vapors fluidize and heat up the incoming material to the desired temperature. Finished dried product is removed through an automatically operated discharge valve. Any finely divided dust carried out in the gas stream is collected in the gas cyclone and returned to the dryer fluid bed.

Volatile gases after passing through the cyclone are sent to the scrubber for final solids removal. Gas leaving the scrubber is metered and passes through a flow control valve prior to entering the recycle gas blower for compression. Gas then enters the steam heat exchanger and is supplied in superheated form to the windbox of the dryer.

Simplicity of the system is illustrated by the fact that the only prime mover is the gas blower. The complete drying system is supplied by D-O. It may be altered to meet specific conditions.

This FluoSolids system was installed in a new plastics plant designed by Crawford & Russell Incorporated, Chemical and Process Plant Engineers, 7 Market Street, Stamford, Conn.

DORR-OLIVER
WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT

not been identified because of limitations in analytical techniques.

Only similar process used in the U.S. is Celanese's oxidation unit at Bishop, Tex. (*Chem. Eng.*, Oct. 17, 1960, p. 92). But this process does not employ the same temperature-control methods, is believed to get only about 10% conversion.

Several firms have built their own pilot plants based on Fenske's data. One unidentified petroleum company is investigating the process for producing oxygenated compounds for flooding oil fields in secondary oil recovery. A commercial unit to handle 5,000 bbl./day feed would be only 5½ ft. in dia. Recirculation of the solid particles, about 30-40 lb./lb. hydrocarbons, would pose a problem no more complex than that encountered in fluid catalytic cracking, says Fenske.

Foaming surface-coatings furnish protection from scorching heat

A new generation of surface-coatings that offer protection from temperatures as high as several thousand degrees Fahrenheit have recently become available. These paints, which offer a new dimension in fire protection, have two characteristics in common: (1) they are all intumescent (swell with heat); (2) they are all relatively expensive.

Dyna-Therm Chemical Corp., Culver City, Calif., has developed a three-component system (called D-65) composed of phosphates and boron compounds in a flexible polyurethane binder. When heated, the components react and foam, forming a layer that resists temperatures as high as 6,000 F. Material costs $98/gal., but a coating only 0.125-mil thick is sufficient. It is now being used on missile launching pads, will withstand the heat of four rocket firings.

Columbia Technical Corp., Long Island City, N. Y., has introduced a coating, called Pyro-Shield, made from ammonium phosphate, an amine and polyhydric alcohol in an oil carrier. This system also bubbles when heated; temperature under the coating remains below 350 F. when exterior temperature is 2,000-5,000 F.

PyroShield can be brushed, sprayed or dipped. It sells for $25-30/gal., must be used in 40-mil thicknesses.

Empire Coating & Chemical, Denver, makes Hel-Met, comprised of ammonium phosphate and borates in a modified alkyd vehicle. The coating has resisted temperatures of 1,700 F. in flame tests. Cost is only $6/gal., but product must be used in 125-mil-thick coatings.

More firms seek profits in low-volume, high-purity metals

American Smelting & Refining has just swung into volume production of nine high-purity metals (antimony, arsenic, bismuth, cadmium, gold, indium, selenium, silver and tellurium) as a result of fast-increasing demand from the electronics and thermoelectric fields.

Volume production, in this instance, means the difference between custom-produced lab quantities and on-the-shelf availability, according to Asarco. Although no quantities were disclosed, one observer estimates it means a jump from 50-100 g./mo. to an output of 50-100 lb./mo.

Finding the proper range for production and distribution within this scaled-down concept of volume offers a real challenge to producers accustomed to dealing in thousands of tons per month. Also, the 99.999+% product purities demand processes characterized by unusually numerous and precisely controlled stages.

With a $40-million market in thermoelectric materials alone predicted by 1965, however, an increasing number of producers both in the chemical and metal industries are expected to find the adjustment worth making.

Continental Oil is piloting a process at Ponca City, Okla., to make alpha-olefins via Ziegler chemistry. Dubbed Alfenes, materials are made from aluminum alkyls and low-molecular-weight aliphatic mono-1-olefins, according to Australian patent 63,330.

Oil-based paints fight to retain markets via water-solubility

Water-soluble linseed-oil-base housepaint, claimed to be the first ever marketed, is now being manufactured by Consolidated Chemical & Paint Mfg. Co., Brooklyn, N. Y.

Makers of conventional oil-base paints, and

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suppliers of drying oils used in these paints, have been intensively seeking such water-compatible linseed oil paints in order to protect their last remaining stronghold—exterior finishes—from further inroads by synthetic latexes. Linseed oil depends upon exterior paints for about three quarters of its total sales. In the last two years, however, latex paints have grabbed off 10-20% of the exterior business by offering water-thinning and easy cleanup properties.

Linseed oil backers are pushing both water-soluble and water-emulsion techniques. Using the water-solution route, Spencer-Kellogg has produced a new linseed oil paint vehicle, called Linaqua, which is 85% solids with a volatile coupling agent to give it water solubility.

Taking the emulsion route are Cargill Corp. and U.S. Dept. of Agriculture at the Northern Utilization Laboratories in Peoria, Ill. Cargill is almost ready to market a linseed oil emulsion vehicle for exterior topcoats.

Unlike synthetic-polymer emulsion paints, the water-base linseed oil compounds are said to adhere directly to old, chalky paint surfaces (where synthetic latexes require an oil-based primer). Linseed oil vehicles also provide good one-coat hiding, high gloss, simplicity of formulation.

Bechtel Corp. has been awarded a $20-million contract for construction of an Isocracker and hydrogen plant at Tidewater's Avon, Calif., refinery. It was not disclosed whether Bechtel will supply the financing that Tidewater had been seeking (Chementator, May 1, p. 32).

Another process bids to desalt sea water by freezing method

North American Aviation's entry into saline water conversion (firm's Rocketdyne Div. is building a 15-20,000-gal./day pilot plant near Oxnard, Calif.) confirms two trends that are emerging from this fast-growing field:

• Rocketdyne is betting on a freezing process for its unit, adding weight to industry opinion that this route offers greatest promise for economical desalting (*Chementator*, May 1, p. 27). Firm's method is similar to the hydrocarbon-refrigerant system being piloted by Blaw-Knox at its Tampa, Fla., plant.

Rocketdyne will employ freezer-washer equipment originally developed by Cornell University's H. F. Wiegandt, as used in one version of Blaw-Knox's flowsheet. A refinement is that the Oxnard unit will eliminate heat exchangers in several sections; heat transfer between water and hydrocarbon will be by direct contact. Company projects a production cost of 40¢/1,000 gal. for a 10-million-gal./day plant.

• Rocketdyne's project is not affiliated with the Interior Dept.'s Office of Saline Water program. Like several others in the field, Rocketdyne sees profits to be made in industrial and municipal markets both here and abroad and is not waiting for government funds before plunging ahead.

The company that has gone farthest in the commercial field is Fairbanks Morse with its Zarchin process (*Chementator*, Feb. 6, p. 35). Firm is now tooling up its Beloit, Wis., works for commercial production of desalting units. Other firms definitely eyeing the commercial market are Blaw-Knox and Scientific Design, which is working with Struthers Wells.

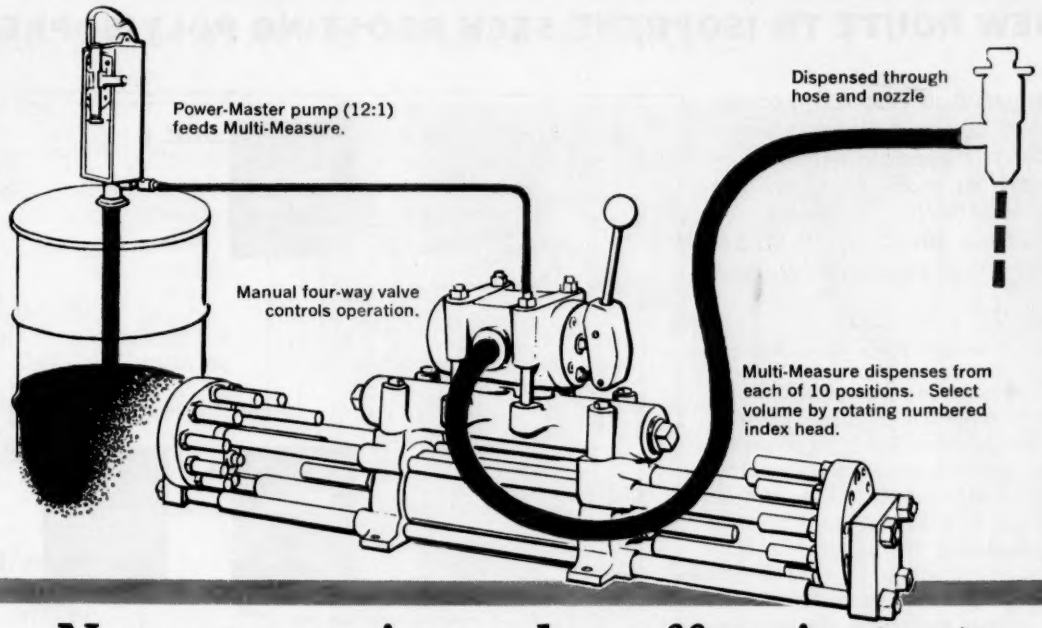
Research and development briefs

Radioactive dating technique, employing two different isotopes, has been developed by researchers at Goodyear Tire & Rubber Co., Akron, Ohio. Method employs two intimately mixed isotopes, one with a long half-life to serve as a measurement standard, the other with a short half-life that acts as the timer. This double labeling method is accurate within 5%, could be used to date materials in storage, measure time needed to dispose of waste in industrial settling ponds.

Recording viscoelastometer for determination of viscosity and elastic recovery of polymers such as polyisobutylene and polystyrene has been perfected by the National Bureau of Standards. It consists of a concentric-cylinder rotational viscometer, having a fixed outer cylinder and rotating inner cylinder. Constant torque is applied to the rotor, then released, in a stepwise manner. Viscosity measurements from 10^6 to 10^{12} poises, and elastic recovery determinations from one second to one day, can be obtained.

For More Industry & Economic News . . . p. 42

New ideas for dispensing materials...from LINCOLN


Power-Master pump (12:1) feeds Multi-Measure.
Dispensed through hose and nozzle
Manual four-way valve controls operation.
Multi-Measure dispenses from each of 10 positions. Select volume by rotating numbered index head.

New measuring valve offers instant selection of 10 different volumes

If your dispensing operation requires frequent changes in dispensing volume, you will save time and speed production by using Lincoln's new Multi-Measure Model 83232. Ten adjustable stop pins let you preset the amount each position will discharge with a range of settings from .5 to 25 ozs. The numbered index heads rotate for rapid switching from one volume to another. The system is ideal for filling different mold cavities with the exact amount of material each requires, filling gear cases, sealed bearings and similar applications.

Lincoln offers a complete selection of measuring valves for precision metering and dispensing of fluid and semi-fluid materials. Whatever your requirements for dispensing materials, consult Lincoln first.

LINCOLN MEASURING VALVE SYSTEMS

Model	Capacity (ozs.)	Max. Operating Pressure (p.s.i.)
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83232	10 positions .5-25 ea.	1500
SINGLE MEASURE		
81849	.045-1	5000
81741	0-4	5000
82232	4-8	5000
82233	8-12	5000
81914	4-48	750

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NEW ROUTE TO ISOPRENE SEEN BOOSTING POLYISOPRENE'S

Two-step French process, based on isobutylene-formaldehyde condensation, is expected to make isoprene for about 10¢/lb., polymer for less than 30¢/lb. U. S., Japanese firms evidence interest.

HELEN AVATI
McGraw-Hill World News, Paris

Polyisoprene's push to gain a sizable proportion of the synthetic rubber business has been strengthened by development of the Institut Francais du Petrole process (*Chem. Eng.*, Jan. 9, p. 35).

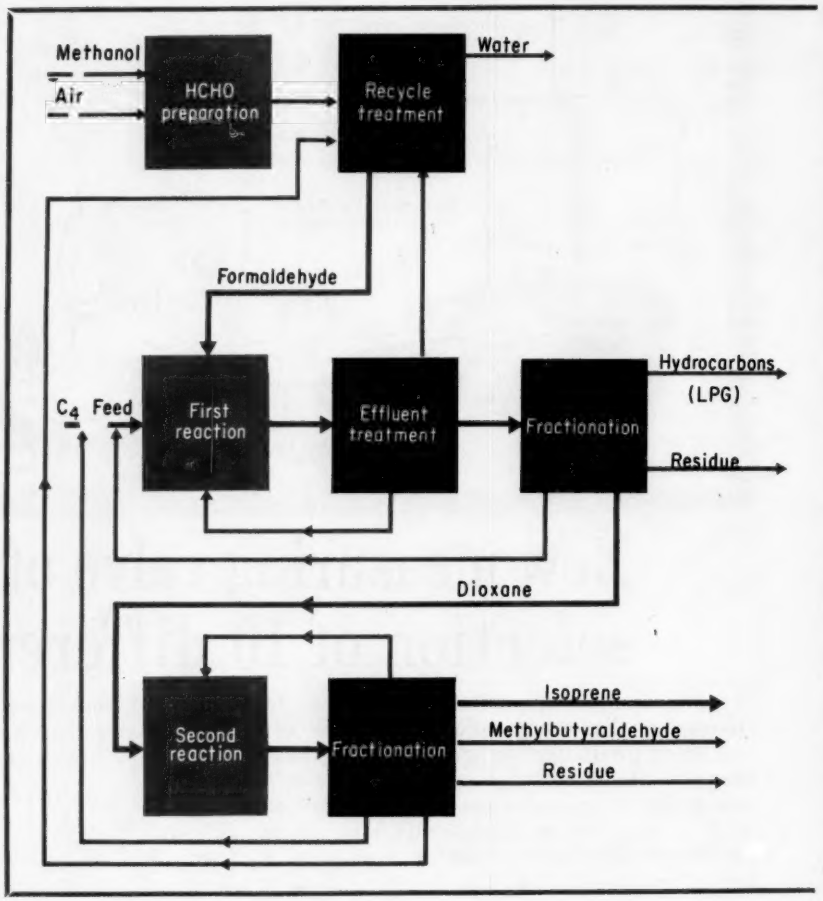
Economics of the process indicate that it will be possible to produce polyisoprene for 22½-27¢/lb., or at least under 30¢. In addition, for every pound of isoprene used in the process, ¾-lb. of a secondary product with an estimated value of 10-15¢/lb. is produced. This could reduce cost of the polyisoprene by 2½-3¾¢/lb.

Now in 90-lb./day pilot operation, at the institute's research center outside Paris, the process has attracted nine licensees or option takers since the end of 1959. Among these: two U. S. companies—El Paso Natural Gas and Cities Service—and four Japanese firms—Mitsubishi Chemical, Nippon Gas, Ube Kosan and Toyo Koatsu, chemical division of Mitsui. Two more U. S. companies hold options on the process; and a French firm is expected to sign an agreement soon, plans to build a 1 ton/day plant next year.

Institut Francais' process is based on the isobutylene-formaldehyde condensation, forming a metadioxane that is decomposed to yield isoprene, water, and formaldehyde which is recycled.

Isobutylene is found in almost all C_4 cracking or thermal reforming cuts, the optimum percentage for the Institute's process is 20-25%.

Optimum extraction rate of isobutylene in the first step of the process must be fitted to the composition of the C_4 cut feed.



The institute points out that its process might be fitted in with a butadiene production plant, the first step being used instead of a cold acid unit in order to remove isobutylene from a C_4 cut used in manufacture of butadiene.

▶**Process Details**—C_4 cuts and an aqueous solution of formaldehyde from methanol oxidation are contacted in a first reactor with an acid catalyst, under pressure at a temperature of about 210 F. The organic phase is neutralized and the unreacted C_4 flashed off. The dioxane is vacuum separated from the heavy byproducts.

In the second stage, the dioxane is catalytically decomposed at atmospheric pressure and a temperature below 750 F. Reactor effluent is cooled, causing it to separate into two layers: the organic phase, which is fractionated to give isoprene and small quantities of isobutylene, plus the unreacted dioxane and a few heavy products; the water phase, which is recycled and mixed with the first-step mother liquor and the effluent of the methanol oxidation reactor.

Main difficulty in developing the process was encountered in the second step—choosing a chemically and mechanically suitable catalyst. Fixed, moving and fluid-bed cata-

SHARE OF SYNTHETIC RUBBER MARKET

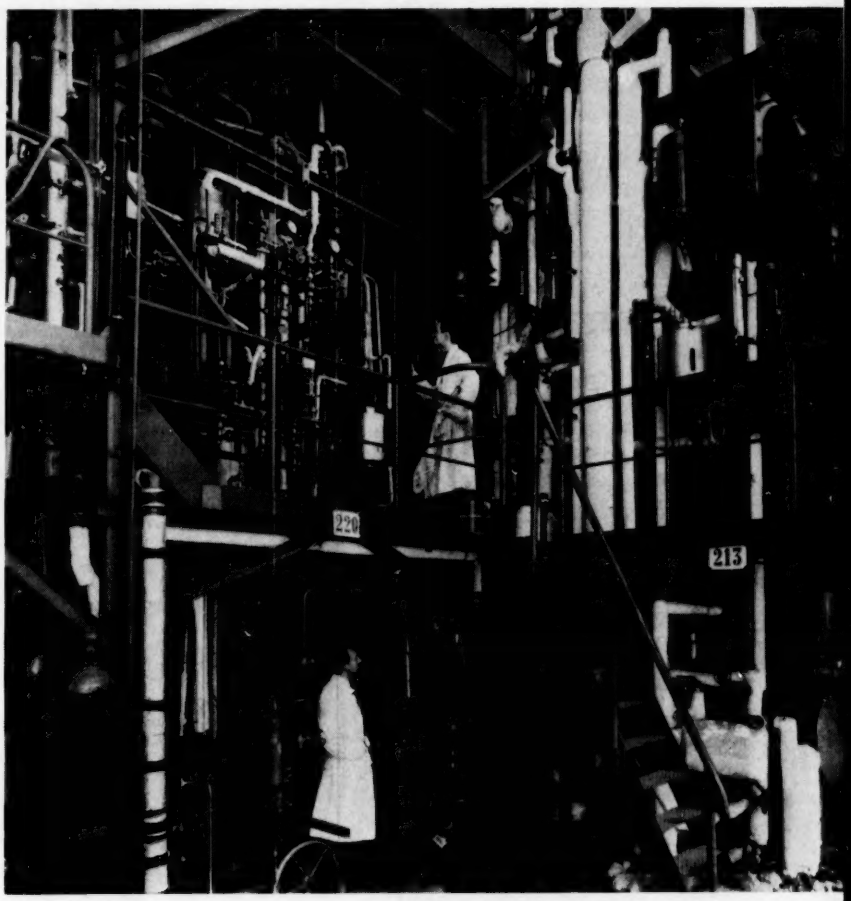
Isoprene—materials and utilities

	Quantity/Lb.
C_4 cut	1.04 lb.
Methanol	0.867 lb.
Steam	7.72 lb.
Cooling water	55 gal.
Electricity	0.145 kwh.
Fuel	13 M Btu

Isoprene—estimated operating cost

(Based on 44,000 ton/yr. unit on Gulf Coast)

Direct Costs	$/Ton
C_4 cut (14¢/gal.)	58.51
Methanol (23¢/gal.)	60.33
Catalysts, chemicals	3.49
Utilities	18.55
Labor	10.80
Fixed Costs	
Depreciation	22.50
Maintenance	9.00
Interest	7.64
Property taxes and insurance	4.50
Royalty	9.60
General plant	2.26
Total	207.18
Credit for byproducts	2.28
Total manufacturing costs	204.90



Institut Francais' pilot plant near Paris provided solution to many problems posed by new process.

lytic systems were studied and compared.

Catalyst life in fixed beds was fairly short, and the frequent regenerations produced severe corrosion conditions. Fluid bed would necessitate a very long development. Therefore, the moving bed was selected and gives excellent results. It can be mixed adibatically; the catalyst circulation speed and volume are rather low. No regeneration device is necessary, and catalyst life is estimated to be several thousand hours.

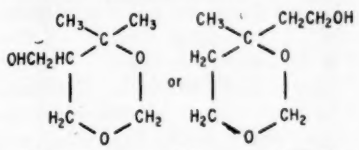
Long duration runs in the pilot unit since Jan. 1957 are said to have provided solutions to these problems and also to those concerning secondary product behavior in the recycle fractions.

Corrosion problems have been carefully studied. In the main part of the unit, carbon steel can be used, but alloys are necessary in the first step where formaldehyde and acid are used.

▶ **Byproducts Obtained**—The stereospecific polymerization requires a high purity monomer. Active hydrogen must be avoided, cyclopentadiene, α-acetylenic compounds and butene-2 must be reduced below 50 ppm., cyclopentene below 100 ppm.

The main byproducts are light, clear oils that contain large quantities of OH groups. They are obtained in both steps of the process. Their distillation ranges from 320-800 F.; densities 1.107-1.135; viscosities at 50 C., 13.5-17.5 centistokes.

Thirty percent of the first step "residue" is a mixture of easily extracted dioxanic alcohols such as:



Several complete engineering

studies of commercial plants have been made by the Institute and its licensees. One example is a 44,000-ton/yr. unit to be erected on the Gulf Coast (see accompanying table). Total investment is $9,925,000 including tankage, engineering and contractors' fees. This corresponds to a grass-roots plant without electricity and steam production, but including cooling water pumping facilities and cooling towers. It also includes formaldehyde production from methanol.

Additional routes to polyisoprene

Since stereospecific polymerization became known, many laboratory studies have been conducted in an effort to find a cheap method of producing the isoprene monomer. Here are four:

- *Dehydrogenation of isopentane by a process similar to Houdry's butadiene process. This method requires high temperatures, catalyst life is short, and a side reaction leads to piperylene, which must be extracted and for which no use has yet been found.*
- *Acetylene and acetone condensation, then hydrogenation and dehydration. Main disadvantage of this process is that raw materials are expensive.*
- *Dehydrogenation of isopentenes. Here, tough problems of purification are involved. In addition, rich, isopentene cuts are not readily available.*
- *Propylene dimerization and demethanization. This process is attractive because raw material is cheap. But it is not easy to avoid side reactions leading to straight chain isomers, and it tends to give rather low yields.*

MORE ALUMINUM SLATED FOR SUPERPURE RATING

Tonnage up, impurities down as superpure-Al producers continue expansion. Here's an inside glimpse of the electrolytic process.

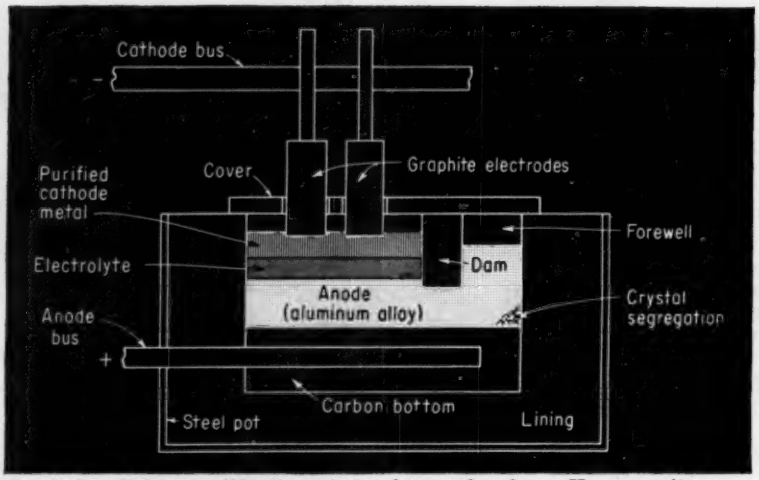
Evidence of the growing demand for superpure aluminum is Kaiser Aluminum & Chemical Corp.'s 55% expansion of its Mead, Wash., plant capacity. Now on stream is potential for 2,650 tons/yr. of the 99.99-plus pure metal.

Just last fall, Consolidated Aluminum Corp. completed a 160% expansion of its Jackson, Tenn., superpure-Al capacity, which at that time made the firm the nation's largest producer (1,800 tons/yr.).

And though the only other known U. S. manufacturer—Reynolds Metals at Listerhill, Ala.—says it has no immediate plans to boost its 600-ton/yr. capacity, magnitude of the other expansions indicates unusual growth that may well continue.

▶ **Here's How It's Made**—All three firms electrolytically refine the superpure metal in modified Hoopes cells, although the modifications vary. Cell sizes, shapes, and product purities differ; Conalco's cell, for example, is a 10-ft.-dia. cylinder that turns out metal at a guaranteed minimum purity of 99.992%, average 99.996%.

Even more basically, Conalco's electrolyte is an all-fluoride mixture, while both Reynolds' and Kaiser's electrolytes are thought to contain some molten barium chloride.



Conalco's cell is a modification of the three-molten-layer Hoopes unit.

Conalco's cell itself is a potlike steel shell, inner-lined by brick, with a layer of carbon on its bottom to encapsulate the anode bus bar (see diagram).

A dam divides the cell into bath and forewell, the bath being composed of three molten layers:

- Heavy bottom layer of impure aluminum, acting as anode.
- Middle layer, the electrolyte, that consists of a delicately proportioned—and secret—mixture of undisclosed fluorides (thought to be BaF_2, CaF_2, NaF and AlF_3, based on information contained in Swiss patent application No. 45666, May 1957).
- Top layer, the resulting superpure aluminum, that serves as cathode.

Graphite electrodes dip into the top layer and bleed the current off through an insulated cell cover. Cells are connected in series to a generator.

▶ **The Theory of It**—As current passes through the cell, Al ions in the molten anode drift up through the electrolyte to the cathode, where they collect as superpure liquid. The more electronegative impurities—such as Si, Fe, Cu—cluster together in the cooler corners of the anode, while the more electropositive ones are dissolved in the electrolyte.

Theoretically, 100%-pure metal

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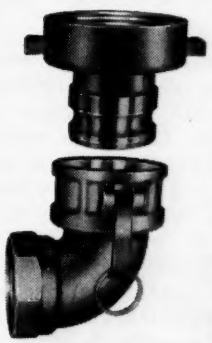

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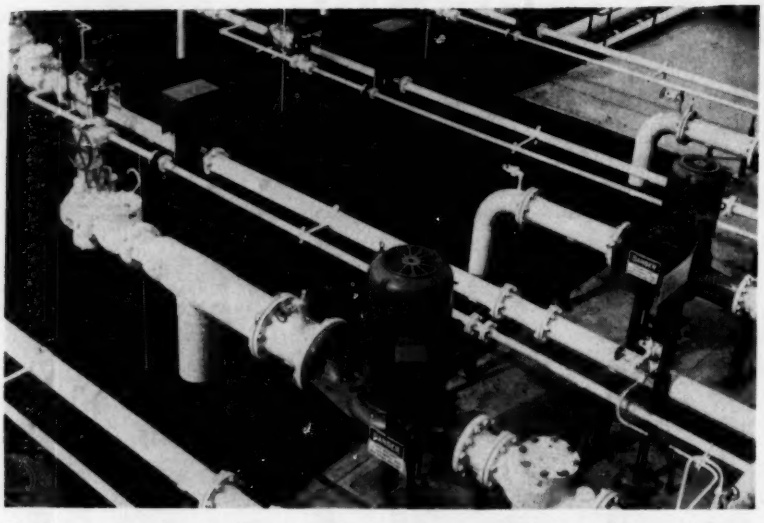
could be attained. In operation, however, Conalco can consistently hit "five nines": 99.999%.

▶ **And the Practice**—Conalco feeds solid 99.3-99.5% pig aluminum into a bank of 26 cells at regular intervals, usually every other day. Cells are tapped for superpure product just before the new charge is added, with tap yield running about 1,000 lb./cell. Power: about 7-8 kwh./lb. of Al refined.



Turbine meters jut up (foreground) from two parallel runs—high and low-range flows—on same stock stream. Control valves are seen in background.

REFINER TURNS TO IN-LINE BLENDING: GETS MORE UNIFORM FUEL MIX

On stream at Wilmington, Calif., with all-digital control, Union Oil Co.'s push-button setup combines up to 21 feed streams.

With 34 turbine meters built into its stock and additive lines, Union Oil Co.'s refinery at Wilmington, Calif., can continuously blend 357,000 gal./hr. of gasolines, diesel and jet aviation fuels—and control the operation to within ±0.25%. One man to push buttons is all that's required.

In a paper presented before the Western Petroleum Refiners Assn.'s April meeting in San Antonio, Tex., Union's A. F. Stribley, Jr., describes the novel installation—first to use turbine meters, first all-digital control system of its kind.

▶ **How It Works**—Two companion in-line blending systems perform separate duties simultaneously. One unit blends 1,400-2,450 gal./min. of three midbarrel-distillate stocks and two additives, while the other blends up to ten gasoline stocks, five additives and TEL at rates of 1,400-3,500 gal./min.

Each of the 21 feed streams at Wilmington contain (1) a centrifugal pump, (2) one or two parallel turbine meters, depending on design flow ranges, and (3) control valves with electro-pneumatic positioners—all separately looped to a solid-state digital control package about a mile away. Meters flash their respective line's flow rate to the computer, which in turn signals the desired value back to reposition each meter's control valve.

▶ **Facility's Layout**—Base stocks are metered into a single stream at control stations adjacent to stock-storage tanks. Resultant mix flows down a blend header to the central control site almost a mile away, where additives and TEL are metered into the stream.

Stock compositions are programmed into the computer by percents; additive solutions in bbl./bbl. of blend; and TEL in cc./gal.

▶ **The Economics**—Complete systems was engineered and built by The Fluor Corp. for $1.5 million, or roughly what it would have cost to install a new tankage and stop-set batch-blend system (a far slower, less accurate substitute).

Further, Union's continuous in-line system required less real estate; saves on operating and maintenance costs; cuts stock and additive losses.

All in all, Union calls it a bargain: "From the day of startup . . . the blender has exceeded expectations."

▶ **The Hardware**—Waugh Engineering Co. furnished the entire electronic control system, complete with turbine meters and amplifiers. Meter sizes range from ¾-6 in.; some are described as new-type turbine design, built around a rotor floating on fluid film.

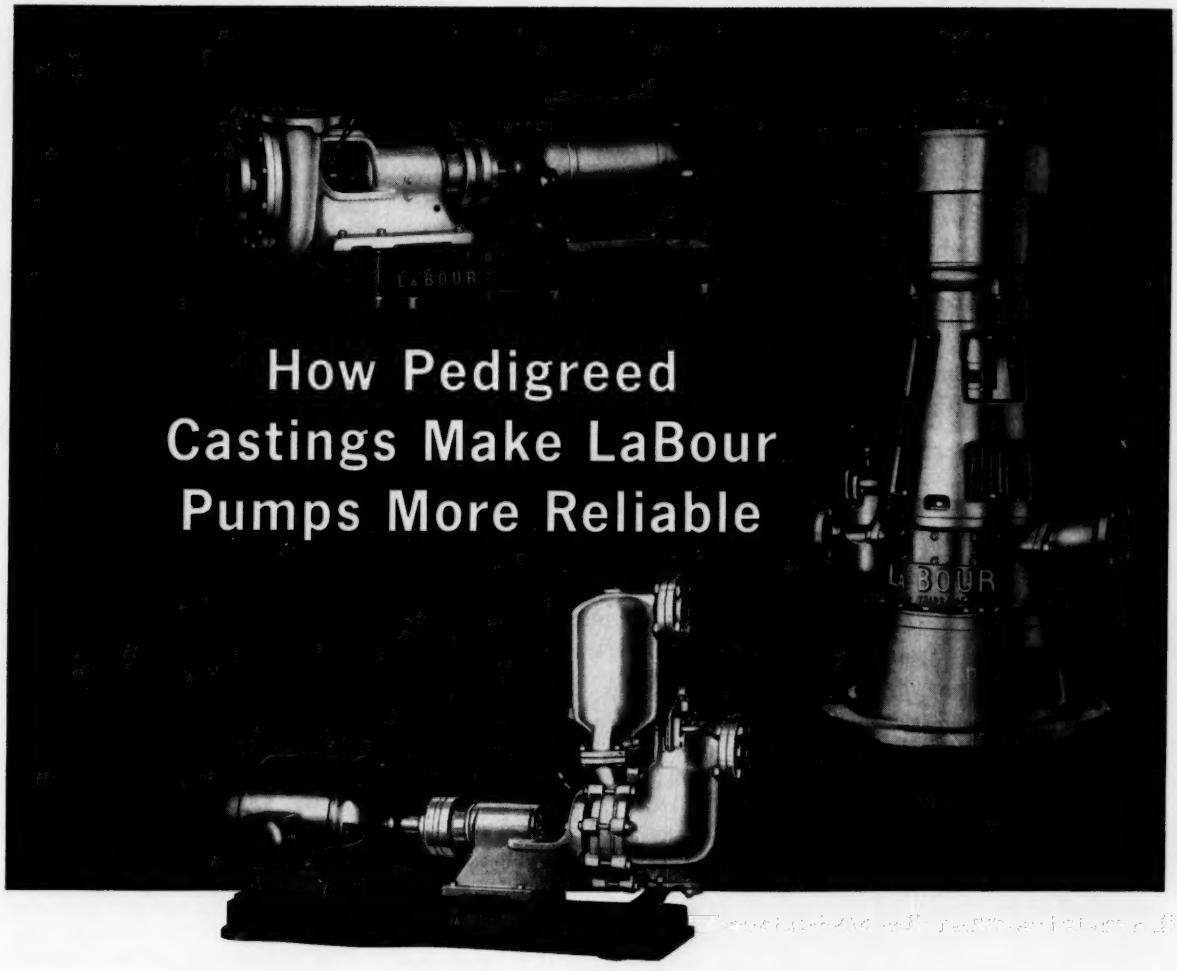
Waugh selected Packard Bell Computer Corp. to manufacture the bulk of the electronic components and to package the control system, although Union retained the rights to—and has patents pending on—the control principle itself.

Vertical in-line centrifugal pumps on stock streams were custom-made by Pacific Pumps, Inc. Flanging directly into the line, they need no foundation. And Mason-Neilan furnished the control valves—again, of new design (bubble-tight, Teflon-seated).

Engineers to Hear About New Cost-Cutting Methods

The cost of everything from pumps to complete plants will receive close scrutiny when the American Assn. of Cost Engineers holds its annual meeting on June 21-23 at the Somerset Hotel in Boston.

Among the papers and seminars



For nearly 30 years LaBour has carefully analyzed and recorded every heat of corrosion resistant alloys cast in its foundries and has permanently identified each casting with its heat.

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(along with authors and discussion leaders) heading up the program on Wednesday, June 21, are: "Economic Choice in Equipment Selection," C. Birkett, Aluminum Corp. of Canada; "Cost of Electric Membrane Demineralization," K. Barnhill, Ionics, Inc.; "Heat Exchanger Costs," by G. Elliot, Alco Products, Inc.

On Thursday, the meeting will include sessions on "Instrumentation Costs," W. Strauss, Foxboro Co.; "Equipment Erection Costs," W. O'Neil, W. P. Foley, Inc.; "Chemical Plant Costs," C. Bierman, Blaw-Knox.

Friday's agenda includes sessions on "Short-Cut Estimating Procedures," S. Gertz, M. W. Kellogg; and "Estimating Operating Costs," J. Black, U. S. Steel.

ORTHO-XYLENE LOOMS AS MAJOR FEED FOR PHTHALIC PRODUCERS

Active promotion of o-xylene as a replacement for naphthalene will end the raw-material shortages that have beset phthalic makers.

Recent developments in phthalic anhydride technology may soon throw petronaphthalene against a new competitor—ortho-xylene—as petroleum refiners vie for the feedstock market once dominated by coal-tar naphthalene.

Scientific Design Co., New York, recently disclosed that its new phthalic anhydride catalyst is now achieving yields of 0.85-0.95 lb. phthalic/lb. *o*-xylene. This is comparable to the best yields obtained with naphthalene in conventional fixed-bed plants. And SD's catalyst, first announced about a year ago (*Chem. Eng.*, July 11, 1960, p. 74) is claimed to function equally well on naphthalene, giving phthalic producers—for the first time—the freedom to select feedstock on the basis of price.

▶ **New Ground Rules**—This change in technology may alter the industry's thinking about the desirability of *o*-xylene as a starting material.

Phthalic producers in the U. S. (with the single exception of Oronite Chemical) have considered *o*-xylene a poor substitute for naphthalene. Theoretically, a pound of *o*-xylene should yield 1.39 lb. phthalic, while a pound of naphthalene yields only 1.16 lb. In actual practice, *o*-xylene yields have been only about half of theoretical. (According to trade sources, Oronite's plant, which was designed for *o*-xylene, gets about 0.75 lb. phthalic/lb. xylene.) In addition, reactor space velocities have been lower with *o*-xylene, causing a 20% drop in throughput.

▶ **Boost Yields and Throughputs**—But SD claims that it now achieves higher space velocities, as well as higher yields, to obtain *o*-xylene performance equivalent to naphthalene on all counts.

The firm says that it has proved these claims on a commercial scale and that several U. S. manufacturers are evaluating the catalyst for their own operations. And SD is building a phthalic plant in France to operate exclusively on *o*-xylene.

The company now is hoping to license its catalyst to U. S. fixed-bed phthalic producers. Changeover, says SD, entails only recharging the catalyst tubes and adding an *o*-xylene vaporization system. The modified plant would work equally well on naphthalene if a switchback became necessary.

For new phthalic plants, the capital investment for an *o*-xylene-based unit is slightly less than for a conventional plant. This is because the liquid *o*-xylene is easier to handle than naphthalene, which must be shipped either as a solid or in the molten state.

▶ **What Price Feedstock?** — With the evident equivalence of feedstocks from a yield standpoint, SD predicts that phthalic makers will turn to price and availability as the basis for selecting a raw material.

Coal-tar naphthalene (78-deg.) is about 95% pure, sells for around 6¢/lb.—freight equalized. Petrochemical naphthalene, which has just come on the market, is over 99% pure, sells for 5.7-6.5¢/lb., f.o.b. The new petroleum sources of naphthalene assure that shortages such as occurred during 1960 are a thing of the past.

Current price of *o*-xylene is 35¢/gal. (about 4.8¢/lb.), f.o.b. Gulf Coast, for 95%-pure material, making it cheaper than naphthalene for equivalent yields of phthalic. Although *o*-xylene has been in short supply because of the boom in exports, the additional capacity coming on stream should soon assure ample supply. In order to stimulate demand, one of the major xylene suppliers, Enjay Chemical, recently started offering long-term contracts to phthalic producers with a clause "guaranteeing a price competitive with naphthalene."

Since *o*-xylene's value as a phthalic feedstock is now 10-15¢/gal. greater than its value in gasoline blending, refiners with aromatics extraction capacity are in a strong position to compete for phthalic markets. And with coal-tar producers saying privately that they can sell naphthalene as low as 3.5¢/lb., if price cutting should develop, petrochemical naphthalene producers could find themselves in a tight squeeze.

Two-Stage Process Recovers Sulfuric Acid From Na_2SO_4

A Hungarian chemical engineer claims that he has developed a practical way to regenerate sulfuric acid and caustic soda from waste sodium sulfate solutions.

Joszef Kerti of the University of Budapest says that his electrolytic process yields a 60% NaOH stream and 40% sulfuric acid, along with byproduct hydrogen and oxygen. Route is intended for use in viscose plants, which discharge large amounts of waste Na_2SO_4. Recovered 40% sulfuric acid is strong

3M COMPANY CHEMICALS

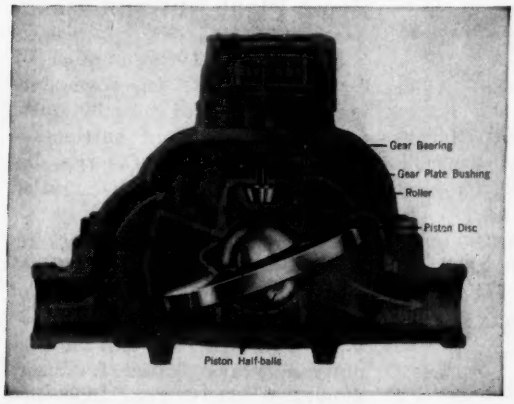
THE RAW MATERIALS OF PROGRESS

KEL-F® withstands corrosive attack— keeps meters on the mark!

BRAND PLASTIC

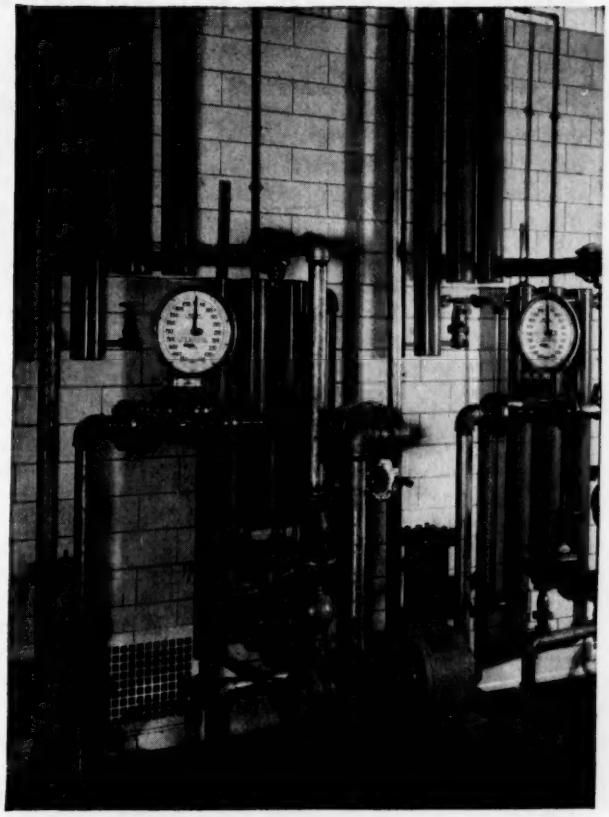
Equipment that measures even highly corrosive liquids can be enduringly exact too! Buffalo Meter Company manufactures meters that measure precisely the flow of over 100 corrosive chemicals including, for instance, acetic acid, aluminum nitrate, carbon bisulfide, diethylamine, phosphoric acid, potassium chloride and concentrated sulphuric acid. Vital parts of the meter—piston discs, half balls and other components—are made of KEL-F Plastic because it retains its shape and dimension in the presence of corrosive chemicals.

KEL-F Brand Halofluorocarbon Plastic solved the meter maker's problem. In addition to the imperviousness of KEL-F Plastic to corrosive chemicals—even fuming nitric acid—this plastic was chosen because of its stability, easy moldability, low cold flow, low specific gravity and good lubricating



qualities. Five meter components, as indicated in the illustration, are made of KEL-F Plastic. They are molded for Buffalo Meter Company by Resistoflex Corp., Roseland, N. J., and the Garlock Packing Co., Palmyra, N. Y.

Other characteristics of KEL-F Plastic—It performs through an unusually wide temperature range . . .



—420° to +400°F. It has unusually high tensile and compression strength . . . can be molded by injection, extrusion, compression or transfer methods, all with a high degree of precision.

For additional information about KEL-F Plastic, write today, indicating area of interest, to 3M Chemical Division, Dept. KAL-51, St. Paul, Minn.

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CHEMICAL DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

enough for use in viscose production. However, no economics of the process have been disclosed.

Process uses a mercury cell in the electrolysis step, removing the sodium as an amalgam as soon as it is formed:

$$2\ Na_2SO_4 + 2\ H_2O \rightarrow 4\ Na + 2\ H_2SO_4 + O_2$$

Current efficiency is over 90%. The sodium-mercury amalgam flows to a decomposition chamber where water is added:

$$2\ Na + 2\ H_2O \rightarrow 2\ NaOH + H_2$$

The two-step method is claimed to circumvent problems inherent in a single-stage electrolysis of sodium sulfate.

AIDING CANADA'S OIL AND CHEMICALS

Despite such bright spots as $270-million sales of natural gas expected by 1965, Canada's process industries have a chronic unfavorable balance of trade.

Both Canada's oil and chemical industries are having profit-margin trouble. The remedy for oil appears to be expansion of exports; for chemicals, curtailment of imports.

But applying "caution" labels to both prescriptions last month were E. D. Loughney, president of British American Oil, speaking before his shareholders, and LeRoy D. Smithers, president of Dow Chemical of Canada, speaking in New York before the Synthetic Organic Chemical Manufacturers Assn. meeting.

According to Loughney, competition for available markets for petroleum products continued to exert extreme pressure on profit margins in refining and marketing operations, with the return on capital invested in these operations still at an unsatisfactory level.

Newly announced Canadian oil policy goals anticipate improvements via a continuing healthy growth in exports of crude oil and natural gas liquids to the U. S. Loughney cautioned, however, against expansions that might cause material dislocation of U. S. domestic production.

As for chemicals, Smithers pointed out that Canada is self-sufficient in most important chemicals. Nevertheless, it imported 24% of its requirements last year, less than half of which were chemicals not available in Canada. Prices have been depressed in an effort to meet foreign competition and, as a result, profits have declined steadily since 1956, failing to respond even to the upturn of 1958–59.

There's growing awareness that the nation's weak tariff structure is a chief culprit. The average Canadian rate for organic chemicals is 8%; for plastics, 4%. Corresponding rates for the European Economic Community are: 22% and 21%; for the U. S., 22% and 39%.

In 1958, the government referred the entire plastics and chemical tariff structure to a board for review. Hearings have been under way for a year, and they will continue at least until mid-1962.

Propylene Carbonate Rids Natural Gas of Excess CO_2

The Fluor Corp.'s process for removing carbon dioxide from natural gas has apparently made a successful transition from pilot-plant to commercial operation. After four months on stream at El Paso Natural Gas Co's Terrel County, Tex., plant, the Fluor-process facility has demonstrated its capacity to reduce CO_2 content of natural gas from more than 50% to about 2%.

In brief, the process consists of an absorber, in which a solvent strips the CO_2 from the natural gas, and a series of flash tanks that release dissolved materials (*Chem. Eng.*, May 30, 1960, p. 46). Propylene carbonate won the job as recirculating solvent over a group of other materials because of its high CO_2 capacity, low vapor pressure and viscosity, and good stability.

Designed to process 220 million std. cu. ft. per day of feed gas, the plant has operated at one third of capacity thus far. Since the absorber system contains three parallel units, one absorber has been operated at full capacity in order to demonstrate design conditions.

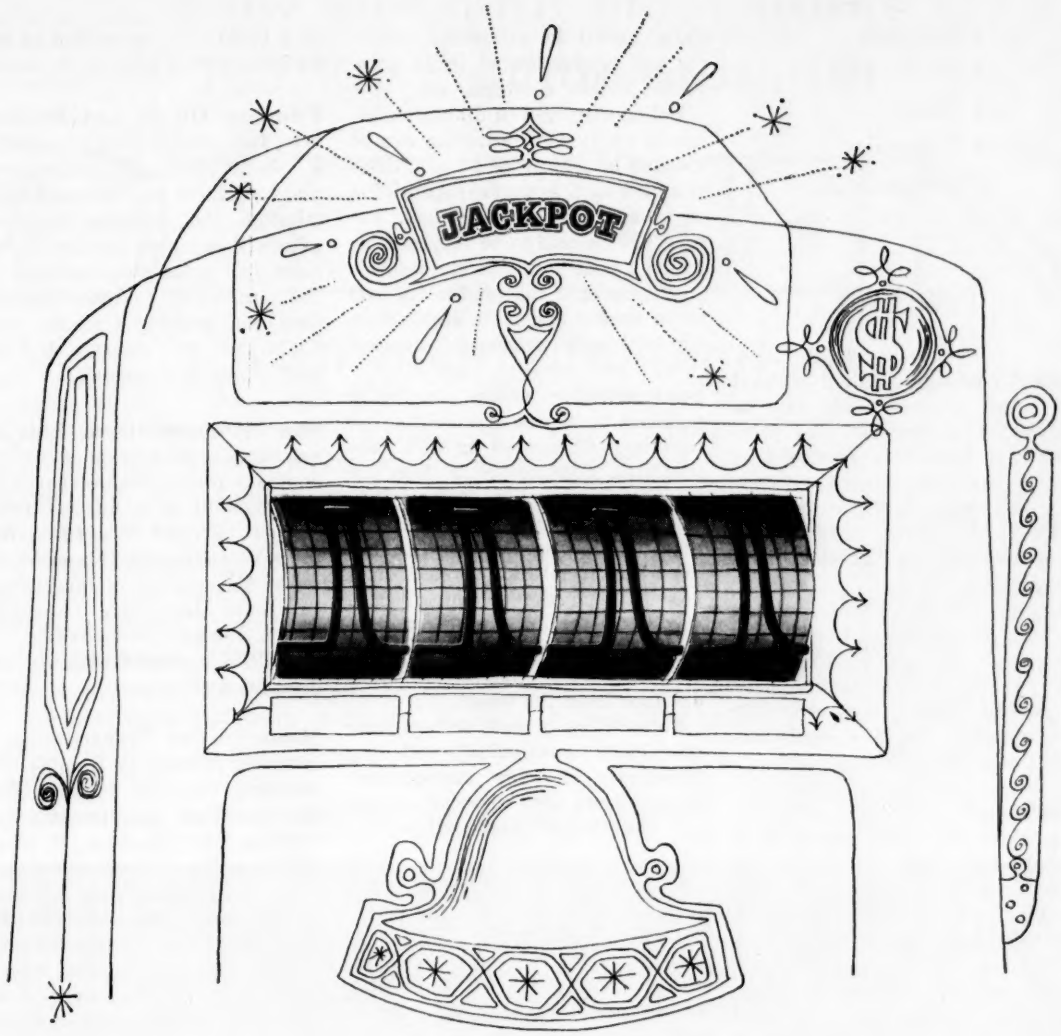
The problem of CO_2 dispersal to prevent suffocating concentrations at ground level was met with a stack having a reduced inside diameter at the top few feet. Effect: CO_2 is expelled with such high velocity that effective stack height is over 1,000 ft.

Concentrated Fertilizers Boost Plant-Nutrient Use

Although total consumption of fertilizer products was down during the year ended June 30, 1960, use of primary plant nutrients—nitrogen, K_2O and P_2O_5—rose because of increasing concentration of mixed fertilizers.

According to the preliminary report just issued by the Dept. of Agriculture, total consumption of fertilizer products was 25,022,000 tons. This was 1.1% less than the previous year. Mixed fertilizers comprised 63.5% or 15,880,000 tons, a 1.2% decrease from consumption the previous year. However, the consumption of primary nutrients was higher by 134,000 tons, reflecting a continued upward trend in use of higher-grade mixtures.

Primary plant nutrients, used in all fertilizer products consumed, totaled 7,571,000 tons, an increase of 2.1% from 1958–59, establishing an all-time record. High-concentration mixtures accounted for over half of the increase in nitrogen consumption and all of the increase in P_2O_5 and K_2O.



With acrylates... purity pays off

Celanese acrylates, made by the beta propiolactone process, provide new high standard of purity

It's a good bet that Celanese acrylates can give you a better finished product. Gas chromatographs demonstrate the unsurpassed purity inherent in this unique Celanese production method. This purity means consistent reaction rates and more complete conversion of monomer to polymer.

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Celanese CHEMICALS

CPI News Briefs

- Processes
- Plants
- Offices
- Companies
- International

Processes

Enamel coatings, applied without the usual ground coat, can be achieved in a new patented process (U. S. 2,981,633) developed by Chas. Pfizer & Co., New York. System uses nontoxic citric acid for pickling instead of sulfuric acid commonly used in the older two-coat method.

Called the Citrobond process, system requires 1 lb. of citric acid for each gallon of pickling solution. While process can be used on ordinary steels, it is especially recommended for the new low-carbon direct-application steels.

Molybdenum catalysts, prepared from crushed arc-cast metal, show exceptionally high activity in reactions such as isomerization, cracking and dehydrocyclization, reports Climax Molybdenum Co. A typical run at 910 F. and 177 psig., using methylcyclohexane feed, yielded a product containing 73.7 wt. % toluene, 20.9% benzene and 5.4% miscellaneous aromatics.

Although the crushed metal catalyst had a low surface area (less than 0.1 sq. m./g.) it exhibited an activity usually associated with catalysts having about 150 sq. m./g. Some of the molybdenum-catalyzed reactions were so rapid that they could not be controlled in the laboratory—complete cracking or destructive hydrogenation took place.

Stable polysulfide polymers, with a potlife ranging from a few seconds to 10 hr., can be made by using an iodine catalyst instead of the usual lead peroxide or cumene hydroperoxide catalysts. Aero Service Corp., Philadelphia, which has patented the process, says the new catalysis technique is especially useful in extending potlife for the production of large polysulfide rubber castings.

Iodine dissolved in dibutylphthalate is used; polymerization can be speeded by adding small quantities of a base such as diphenylguanidine or an acid such as oleic acid. Results are claimed to be reproducible under a wide range of atmospheric conditions and the product is said to be harder and more stable than conventionally produced polymers.

Semiconductor wafers are being polished by a new electrochemical technique discovered by Bell Laboratories. Semiconductor slices are mounted on a nonconducting disk, and electrical contact is established; then the disk is placed on a polishing wheel over which an electrolyte flows. When the polishing wheel rotates, a thin film of electrolyte automatically maintains the semiconductor at a relatively constant distance from the wheel.

In addition to cost savings over the older mechanical polishing techniques, the new method produces wafers with superior surface and electrical characteristics.

Plants

Sharon Steel Corp. plans a $17.5-million factory at its Roemer Works in Farrell, Pa., to produce 1 million tons/yr. of raw steel by the Stora Kaldo process. Unit will be the first commercial U.S. installation to use the Swedish basic-oxygen method, which differs from the well-established Linz-Donawitz route in its rotating furnace (L-D's is stationary).

Texas Eastern Transmission Corp. has begun digging two new underground caves, to cost a total $3 million, in which to store butane and isobutane at both ends of the Little Big Inch pipeline. A 16-million-gal. cavern is being mined in shale, beneath Todhunter, Ohio; a 20-million-gal. cavity is being leached from salt, under Mont Belvieu, Tex. Meanwhile, construction progresses at Princeton, Ind., on a third cave scheduled to hold 6 million gal. of LPG by November.

Tidewater Oil Co. and **Air Products, Inc.,** jointly plan to construct a 60-million-lb./yr. oxo-alcohol plant adjacent to Tidewater's Wilmington, Del., refinery. Air Products will engineer the facility and have full sales responsibility for the planned output—iso-octyl, decyl and tridecyl alcohols—while Tidewater will operate the unit and supply raw materials.

The Marquardt Corp. has been awarded a $4-million Air Force contract for further research and development of a nuclear ramjet engine (Project PLUTO). Work is to be continued in conjunction with University of California's Lawrence Radiation Laboratory, which was responsible for PLUTO's reactor-feasibility demonstration program.

Monterey Gas Transmission Co. has been created by **Humble Oil & Refining Co.** and Lehman Bros., the New York investment firm, to pipeline 6.2 trillion cu. ft. of natural gas from reserves in southwest Texas to various customers in the South. Columbia Gas System, Inc., says a system member will soon sign a longterm purchase contract with the newly created pipeliner. Already committed to buy 700 million cu. ft./day is United Fuel Gas Co. in Alexandria, La.

Susquehanna-Western, Inc., is on stream at Falls City, Tex., producing 300 tons/day of uranium concentrates. The mill, which cost $3 million, uses a solvent-extraction technique on ore from the Luckett mine about a mile away.

Texas Gulf Sulphur Co. has awarded Harrison International of Miami, Fla., the shaft-sinking and underground-construction contract for Texas Gulf's potash bed near Moab, Utah. (Milling plant and other surface facilities are already under construction by

CPI News Briefs continue on page 122

How McLouth Steel stores 160,000 gallons of liquid

OXYGEN

with negligible boil-off

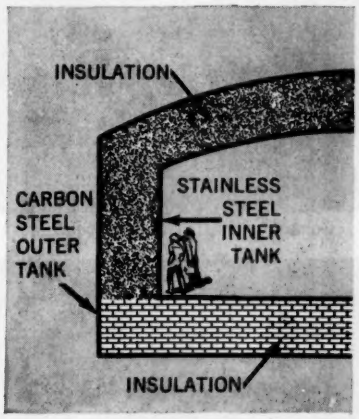
McLouth Steel Corporation needed a large-capacity vessel for storing liquid oxygen at its Trenton, Michigan mill. CB&I fulfilled the requirement with this 52 ft. diameter, specially-insulated, double-wall dome roof tank.

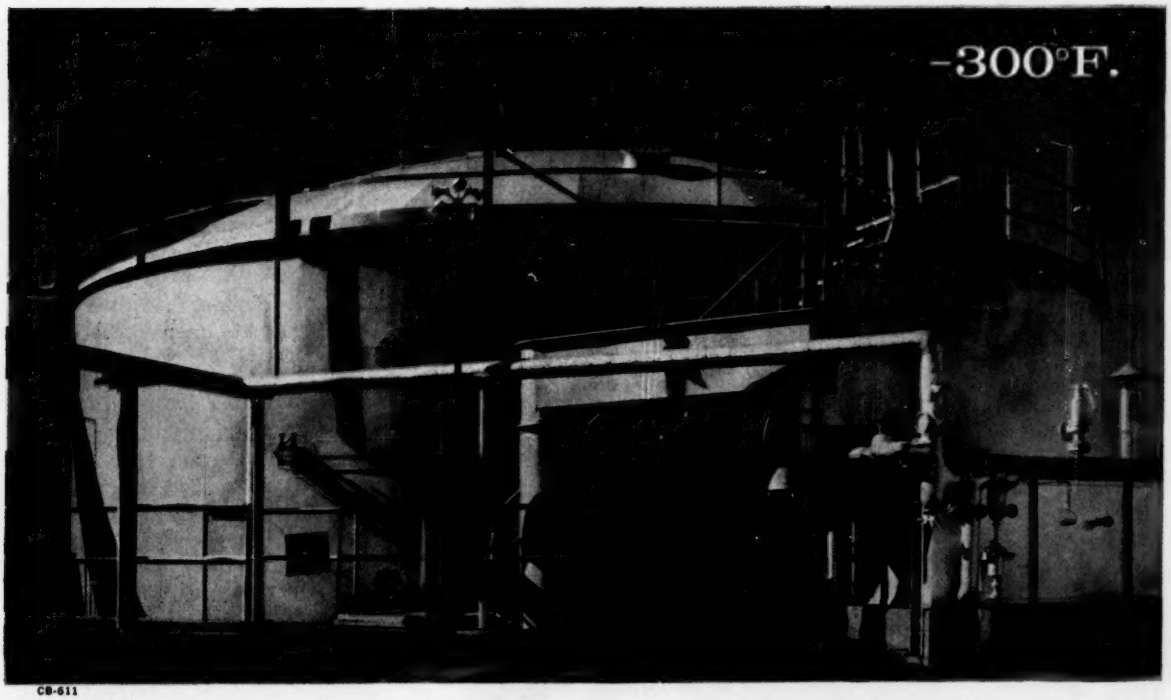
The 160,000 gallons (about 800 tons) of liquid oxygen it stores is kept at a constant −300°F. The six-foot space between the walls, twice the usual insulation provision, assures negligible boil-off.

A second tank recently completed for McLouth, is evidence of the success of this CB&I design.

You will value the depth of CB&I's experience in designing and building cryogenic storage tanks. That's why it pays to start your investigations by calling CB&I.

Write for our Brochure G-50, "Cryogenic Storage Vessels."





CB-611

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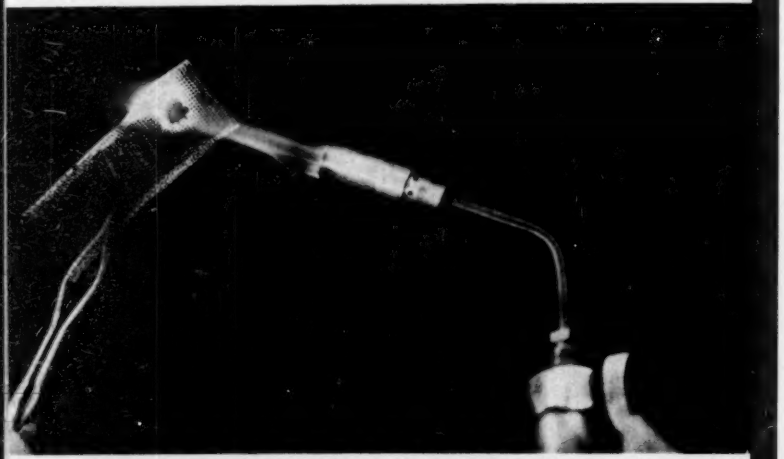
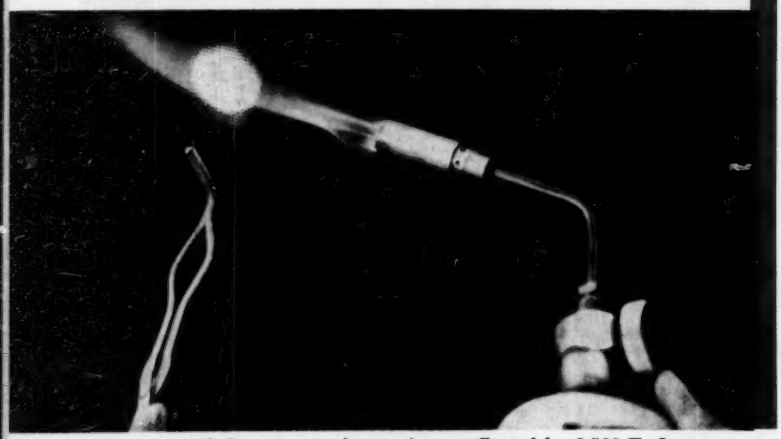
NEW CEMENTS MEET HIGH-TEMPERATURE SEALING NEEDS

Cement cone, formed by nesting two paper cups, resists 5,100 F.



Uncoated screen mesh melts quickly at high heat.



Cement-coated screen mesh remains unaffected by 3,500 F. flame.

Easy to apply and quick to set, cement pastes can boost the heat resistance of metal, ceramic and refractory bonds to 5,300 F.

A new line of cements, called Astroceram, can now be used as bonding agents and sealants at working temperatures as high as 5,300 F., without cracking or vitrifying. Other cements usually fail at temperatures between 3,000 and 4,000 F.

Besides the applications shown above, these materials can also go into casting of thermocouple wires, to prevent oxidation and corrosion at high temperatures; in upgrading firebricks; in welding and brazing of glass, quartz, zirconium, alumina, ceramics and metals; and eventually in missile nose cones.

Offered in three different formulations with consistency ranging from that of free-flowing fluids to butter, Astroceram cements can be air-dried or fired to achieve a bond.

According to Kurt Cornely, chief chemist at American Thermocatalytic Corp., the cements lend themselves easily to several forming techniques. Even the simplest devices can be used: sprayed or brush-coated to a cardboard object, for example, the cements are then exposed to intense heat, which disintegrates the cardboard, and the finished form may be ground with a diamond wheel to desired thickness.

Although rather expensive—$5.75 to 7.25/lb. for small quantities—these materials are worth the price because of their special properties; i.e., a maximum service temperature of 5,300 F., thermal conductivity of 23.2 Btu./hr. (sq. ft.) (F./in.), thermal expansion of 5×10^{-6} in./F., tensile strength of 10,000-20,000 psi., compressive strength from 80,000 to 150,000 psi., porosity between 0-0.2%, and hardness of 8-9 mohs.

Houdry blueprint for dehydrogenation utilizes Mutual Chromium Chemicals

Houdry Process Corporation, Philadelphia, Pa., uses Mutual® Chromium Chemicals as basic ingredients in their chrome-alumina catalysts. They have found that Mutual quality meets their stringent specifications. This consistent purity is important to catalytic life and performance in the unique one-step dehydrogenation process developed and licensed by Houdry for producing butadiene from normal butane.

This is just one of the many ways versatile Solvay® Mutual Chromium Chemicals serve applications ranging from metal treatment to fireworks. To fill your needs for any of the Mutual Chromium Chemicals, look to Solvay. With over 100 years' experience in their development and production, Solvay is the world's largest chromium chemical producer.

For a full description of the Mutual line of chromium chemicals, uses, properties, and comprehensive technical data . . . write for your free copy of Solvay's new 80-page Technical Bulletin No. 52, "Chromium Chemicals."

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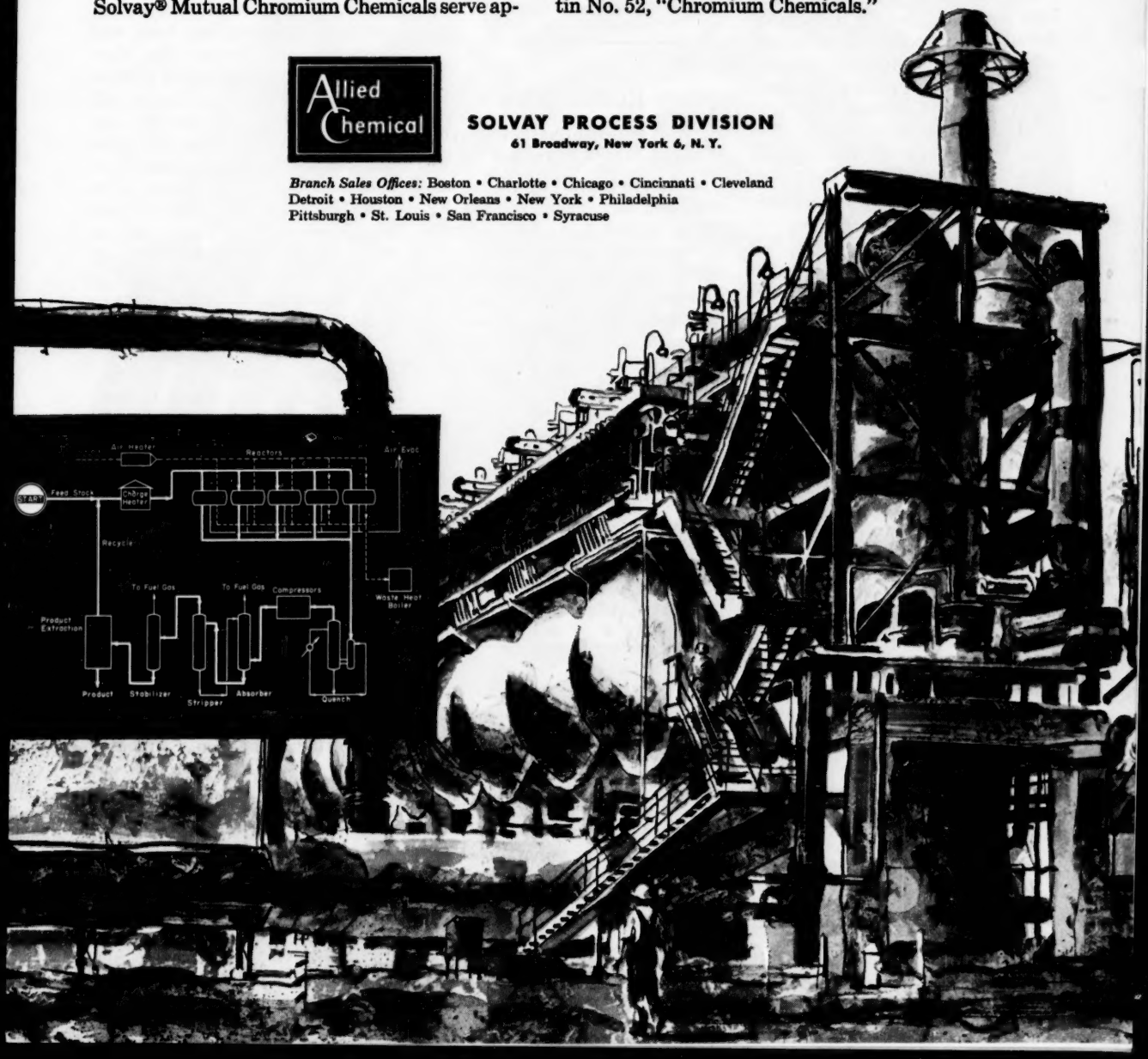


They are insoluble in HCl, HNO_3, H_3PO_4 and H_2SO_4, will also resist CO, CO_2, H_2O, O_2 and hydrocarbons at temperatures over 1,800 F.—**American Thermocatalytic Corp., Mineola, New York.** 54A

Boron silicide

Crystalline compound shows high resistance to oxidizing atmospheres.

Believed to be the only high-boron content material that can be used for extended periods at 2,550 F. in air, B_6Si is available as a black, microcrystalline, free-flowing powder of about 74 microns.

In the family of refractory borides and silicides, this recently developed compound is exceptionally resistant to oxidation because, upon exposure to high temperatures in air, it forms a thin, protective boron-silicon-oxygen coating. The compound's high thermal shock resistance is partially due to the low thermal expansion coefficient.

Oxide-bonded B_6Si and B_4Si plates (2.5x2.5x0.3 cm.), for example, have been cycled without cracking from 2,000 F. to 77 F., by means of alternate furnace heating and air blasting. These plates can also be water quenched from 2,000 F. without shattering.

Since tetraboron silicide breaks up ($3\ B_6Si \rightarrow 2\ B_4Si + Si$) when exposed to about 2,190 F., most preparations of B_6Si contain slight traces of B_4Si. But in the new powder, free silicone—a most objectionable impurity—is kept at the low levels of 0.1-0.15%.

Boron silicide powder can be fabricated by the usual metallurgical and ceramic techniques; it can be hot pressed to give very dense bodies, slip cast, oxide or self bonded.

B_6Si can replace other boron materials, such as boron carbide and boron nitride, that in many refractory applications cannot function at high temperatures in air. It is also applicable for shielding in nuclear reactors and as a burnable poison to absorb excess neutrons.—**Allis Chalmers Mfg. Co., Milwaukee.** 56A

For more information about any item in this department, circle its code number on the Reader Service Postcard (Page 151)

Newsworthy Chemicals

Page number is also reader service code number

New cements meet high temperature sealing needs.....54A
Boron silicide can be used in air at 2,500 F.....56A
Rubber latex boosts adhesion of nylon or rayon to rubber.....56B
Fluoro elastomer resists corrosion attack up to 600 F.....56C
Silicone-base paints won't blister or burn.....56D
New nylon dye claims better leveling and covering properties.....56E

For more details use Reader Service Card

Rubber latex

Material boosts adhesion of nylon or rayon fabrics to rubber.

Made from vinyl pyridine, styrene and butadiene, Pliolite VP-100 is a new latex recommended for tire-cord dips to improve adhesion between the tire fabric and rubber carcass, particularly in tubeless tires. It can be used as the main ingredient in fabric dipping compounds or blended with other synthetic latices.

Reportedly, Pliolite VP-100 reduces cord fatigue, has better processing characteristics and excellent mechanical, chemical and storage stability. These advantages, combined with improved adhesion, should lessen the chance of ply separation in the finished product.—**Goodyear Tire & Rubber Co., Akron, Ohio.** 56B

Elastomer

Tubing material resists corrosion, won't swell in contact with petroleum products.

A new fluoro elastomer, Fluran F-5000, has been designed to resist several corrosive chemicals, fuels and lubricants at maximum operating temperatures that range from 400 F. in continuous service to 600 F. in intermittent use.

Although the chemical nature of this material has not been disclosed, the manufacturer says the elastomer can be used in oilfield piping because it won't lose its strength or swell in the presence of oil. And Fluran parts strongly resist oxidation and weathering.

Available in tubing, hose and press-polished sheets, the elastomer comes in hardnesses of 60 to 95 durometer Shore A. Die-cut and clicked gaskets can also be supplied to meet individual specifications. At room temperature, Fluran's tensile strength ranges from 2,000 to 3,000 psi. and ultimate elongation varies from 100 to 400%. Held compressed for 70 hours at 250 F., it recovers 90 to 97% of its original dimensions.—**U. S. Stoneware Co., Akron, Ohio.** 56C

Briefs

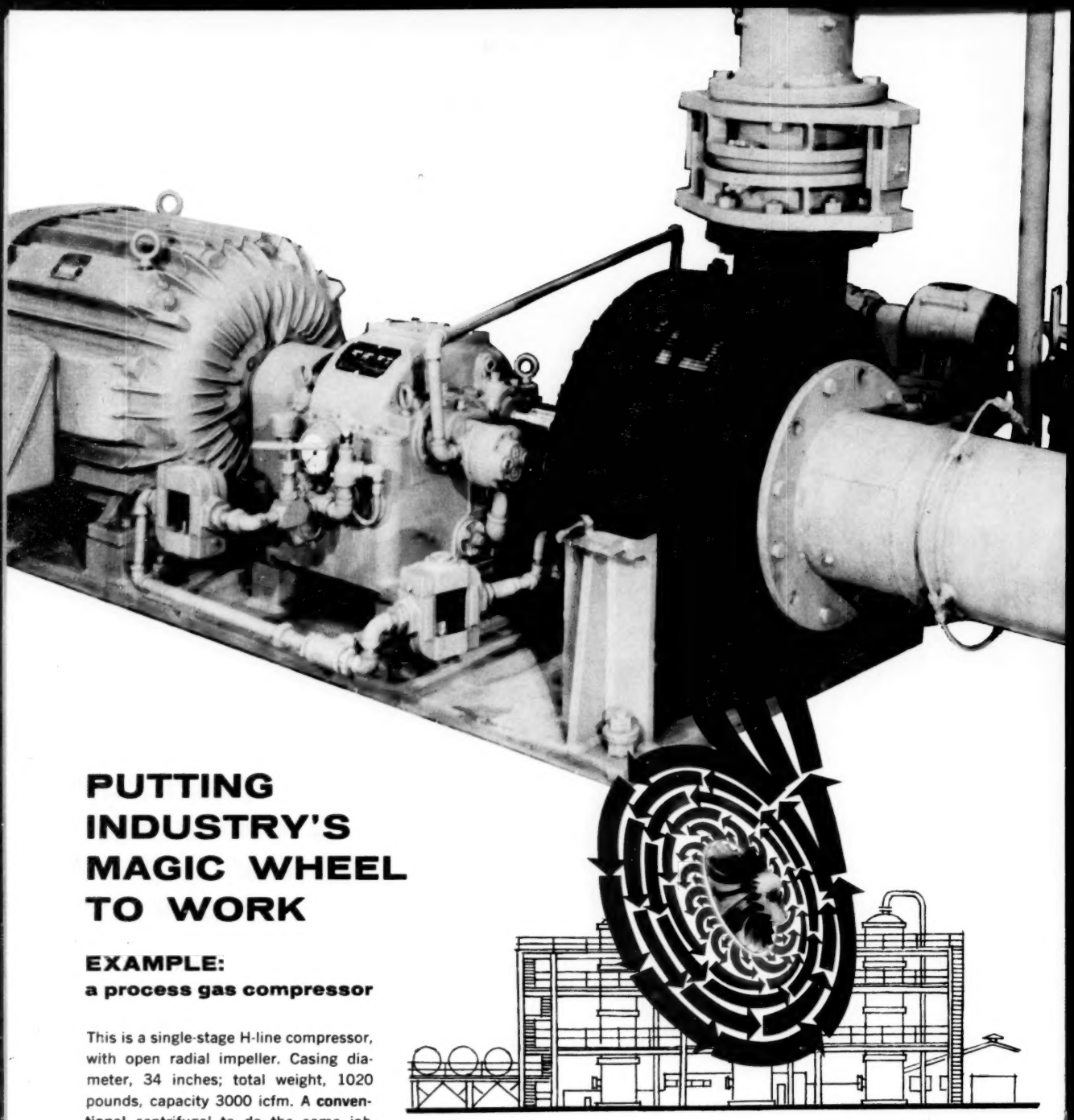
Silicone-base paints, named C-I, blended with a special aluminum pigment withstand temperatures upto 1,700 F., without blistering or burning. C-I air-dries to a bright finish in about 30 min. and the resulting metal coating resists moisture, mild acids, alkalis and fumes. Paints can be used on condensers, ovens, engine heads, compressors, mufflers, radiators. —**Chem Industrial Co., Brooklyn, Ohio.** 56D

Nylon dye Nylanthrene Scarlet 2GL p.a.f. closely approximates the bright acid dyeing scarlets with superior leveling and covering properties on the nylon.—**Althouse Chemical Co., Reading, Pa.** 56E

INDUSTRY'S MAGIC WHEEL

This is an open radial impeller . . . the heart of the Elliott H-line centrifugal compressor. The H-line compressor will ■ do more work ■ handle more gases ■ serve more applications than any conventional design. It permits dramatic reduction in compressor size and weight, facilitates Iso-cooling, and extends the advantages of **centrifugal** compressors into entirely new fields of application.

ELLIOTT
Company



PUTTING INDUSTRY'S MAGIC WHEEL TO WORK

EXAMPLE:
a process gas compressor

This is a single-stage H-line compressor, with open radial impeller. Casing diameter, 34 inches; total weight, 1020 pounds, capacity 3000 icfm. A **conventional** centrifugal to do the same job would be a 3-stage unit weighing about 9000 pounds.

Because corrosive gases will be handled, outer casing and all internal parts are made of stainless steels. This is economically feasible with Elliott H-line compressors due to their extremely small size and resulting light weight.

The one-piece, radial-bladed impeller has no cover or shroud member to create bending and hoop stresses.

Elliott H-line compressors include a wide variety of sizes and capacities, from 300 to 40,000 icfm.

The dependability of these compressors is proved by many years of operating experience with thousands of Elliott machines of similar design.

For specific information, call your Elliott district office, or write Compressor Department, Elliott Company, Jeannette, Pennsylvania.

ELLIOTT THE MOST COMPLETE LINE OF **INTEGRATED COMPRESSOR & DRIVER UNITS** 500 cfm to 600,000 cfm

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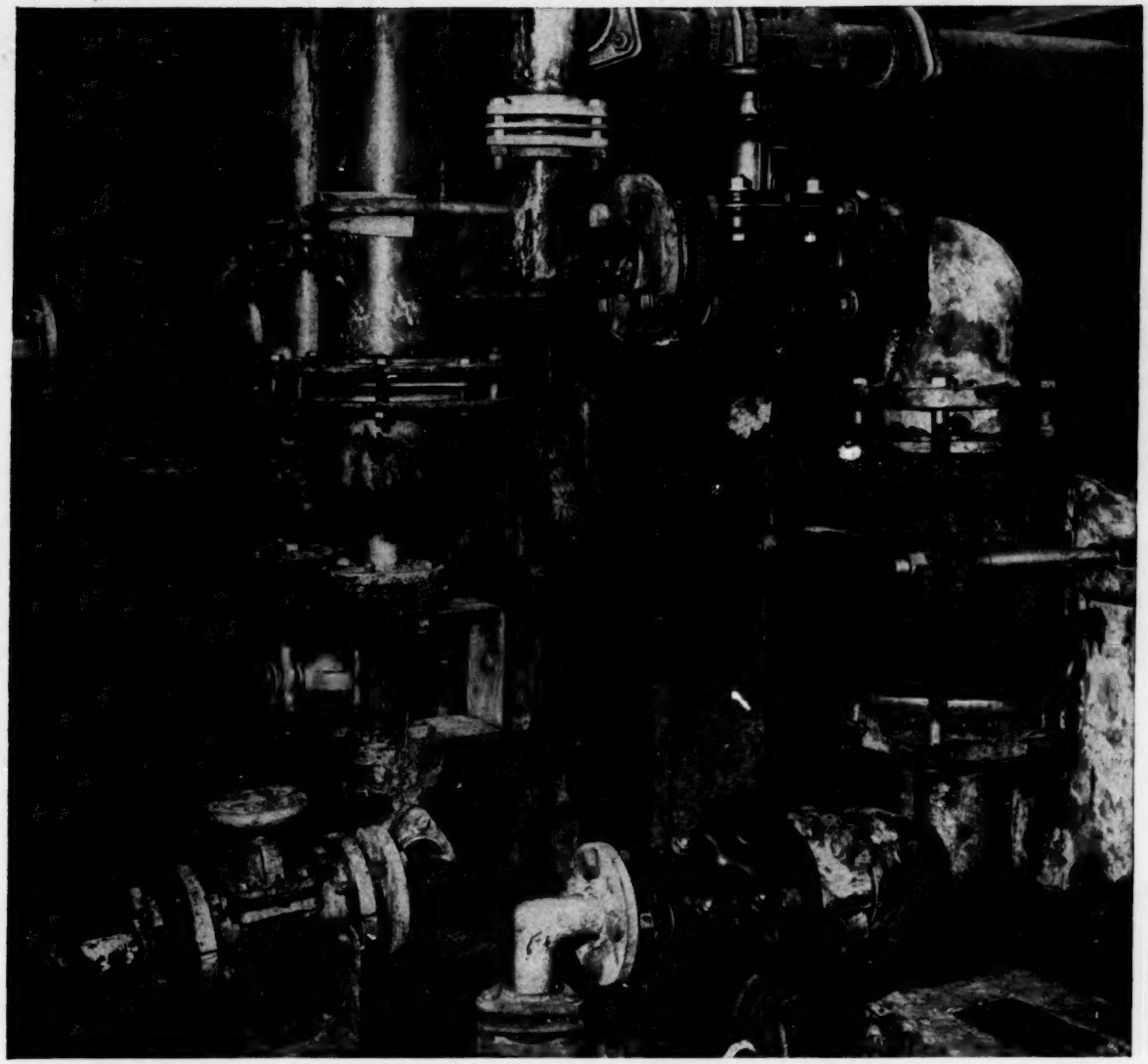
PI-1



Encrustation on two of the above valves was cleaned off to show lack of external corrosion. Compare this with the corroded condition of the structural steel.

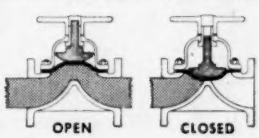
Grinnell-Saunders Diaphragm Valves resist attack by hot corrosives at Carborundum Metals Company

During the past few years, Carborundum Metals Company, a Division of the Carborundum Company, has installed over 200 Grinnell-Saunders Diaphragm Valves at their Parkersburg plant in West Virginia. These valves were coated internally and externally with Penton* —and were equipped with fluorinated plastic diaphragms, backed with elastomer cushions. Their job: to handle highly corrosive caustic soda and sodium hypochlorite–at 212°F, and methyl isobutyl ketone, hydrochloric acid, sulphuric acid at 130°F–all used in processing zirconium ore for zirconium and its co-product, Hafnium.

Today, this manufacturer reports that after being in operation an average of two years, the rugged Grinnell-Saunders Diaphragm Valves are still giving good service. What's more, they've never had to replace parts in these Grinnell Valves!

In Grinnell-Saunders Valves, the diaphragm lifts high for streamline flow – seals *tight* for positive closure. Working mechanism is completely isolated from material in the line to prevent corrosion and contamination. There's a wide choice of body, lining and diaphragm materials, too. See how Grinnell-Saunders Diaphragm Valves can help *your* installation.

Write Grinnell Company, Providence 1, Rhode Island.



* *Reg. T.M., Hercules Powder Co.*

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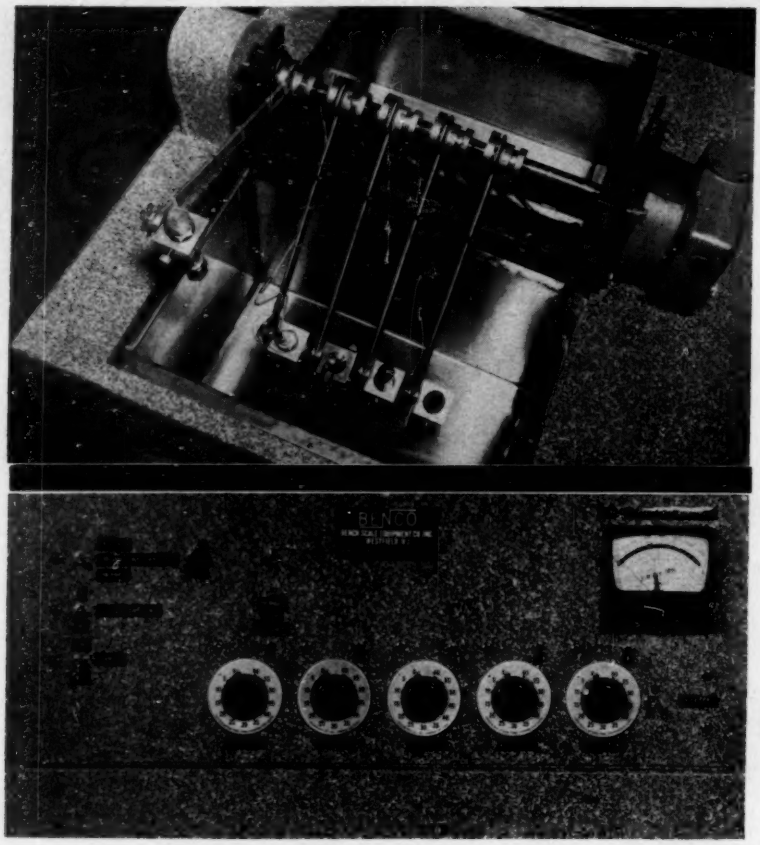


KINETICS KIT SPEEDS VARIABLE STUDY WITH NUMEROUS SMALL REACTORS

Reaction systems are placed under agitation at elevated temperatures, then quenched automatically in any sequence to limit reaction time.

"I'd like to have another data point, but the lab can't run the reaction at the higher pressure," says an engineer designing a pilot plant. "And I'd also like to know the exact point to cut off the reactions to maximize yield."

Both these problems, and many others dealing with chemical kinetics and reaction variables, may be solved with a new instrument for the engineer called Kinetics Kit (KK).

KK provides a means of rapidly and safely placing a number of reaction systems under agitation at elevated temperatures, followed by automatic transfer to a quench or low-temperature environment. The influence of variations in temperature, reaction time and reaction ratios can be measured by multiple tests—up to 15 or more simultaneously.

▶ **Equipment and Operation**—Basically, KK is a device for agitating a reactant mixture at a preset temperature, then quenching or cooling the products. Additional equipment and built-in controls give it a versatility that enables it to pinpoint data from rather complex reactions.

The standard unit consists of five vibrator arms that can implement complete mixing in containers that are sized from capillary tubes to stainless steel reactors holding up to 25 cc. To initiate reaction, the tube holders are placed in an oil bath whose temperature is controlled from ambient to 500 F.

Reaction time, with agitation for the individual arms, may be controlled automatically from 30 seconds to 1 hour. As each reactor reaches its preset reaction time-limit, the arm transfers the reactor to a cooling-bath quench within two seconds. For reaction periods longer than one hour, the arms may be manually operated.

▶ **Attachments Increase Effectiveness**—Reactions that are highly exothermic may be monitored for temperature increase during the operation by insertion of a thermocouple directly into the reactor. Small steel bombs used for this service will withstand up to 2,500 psi. for those reactions that develop pressure during the cycle.

If desired, the reactors can be set up with flexible connections extending outside the unit, for sampling or monitoring gaseous products or for the addition of additional reactants during the test period. Custom models of KK may have each reactor arm provided with an individual compartment, giving a different-temperature bath for each reactor.

▶ **Other Applications**—In addition to the study of process variables, KK may be used to obtain liquid-liquid distribution data at elevated temperatures, for corrosion studies where rate data are needed, and for providing basic information on hazardous reactions.

By processing small samples, and by protecting the operator with a special cover arrangement, the instrument can be safely used to investigate the extreme process conditions that may render a reaction dangerous or uncontrollable, defining these extremes before the process is operated on the pilot level.

Under development is a unit for high-temperature reactions — in the range of 1,000-2,000 F. The present standard unit comes equipped with two insulated

Now, The Slurry Pump The Process Industries Are Asking For

NEW MORRIS TYPE JC

STANDARDized
for simplified maintenance

Competitively priced with the plus economies of lower maintenance costs and smaller parts inventory

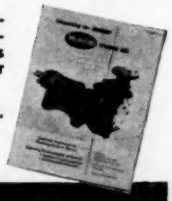
Especially engineered for handling abrasive slurries, this new Morris JC pump is the greatest forward step yet made toward optimum standardization of parts. Offering a choice of 11 models and 5 sizes on only 3 bearing frames, all wetted parts are interchangeable among the sizes of each bearing frame. Other benefits are obvious and many, including:

- **Maintenance men knowing one model are completely familiar with the other 10.**
- **Conversion of a pump to a different slurry service accomplished in minimum time at minimum cost.**
- **Replacement parts available as needed, reducing downtime to rock bottom.**
- **Low parts inventory permits stocking of different alloys for pump changeover to new slurries as needed.**
- **11 models with sizes of 1", 1½", 2", 3" and 4".**

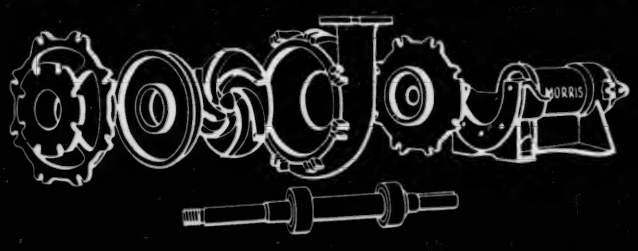
A product of the widest slurry-handling experience in the industry, plus operational tests in the completely-equipped Morris slurry laboratory, the new JC offers proved resistance to combined abrasive-corrosive slurries in an exceptional pump designed around advanced hydraulic principles.

GET THE COMPLETE PICTURE on the outstanding capabilities of this new pump . . . particularly the dollar-and-cents savings beyond its competitive price! Write for Bulletin 191 for detailed information.

MORRIS MACHINE WORKS, Baldwinsville, N. Y.
97 Years of Building Centrifugal Pumps
Agents in Principal Cities



Within the Pump Sizes for Each Bearing Frame, all Wetted Parts are Interchangeable:



Frame No.	Size	Model	Impeller Min.-Max.	Size Solids
Frame #1	1"	JC 8	5"— 8"	¾"
	1	JC 11	8"—11"	¾"
	1½	JC 8	5"— 8"	¾"
	1½	JC 11	8"—11"	¾"
	2	JC 8	5"— 8"	1⅛"
	2	JC 11	8"—11"	1⅛"
Frame #2	1½	JC 14	11"—14"	¾"
	2	JC 14	11"—14"	1⅛"
	3	JC 11	8"—11"	1⅛"
Frame #3	3	JC 14	11"—14"	1½"
	4	JC 14	10"—14"	1½"

stainless steel tanks with heater and temperature indicator/controller good to 500 F., five agitator arms and holders, five variable range timers, motor drive and complete electromechanical mechanism, and a control panel.—**Bench Scale Equipment Co., Westfield, N. J.** 60A

Storage tank

Unit can hold 3.75 gal. of acids, corrosive liquids, or hot water.

Whether used for quiet storage of liquids or for temporary storage in a processing system, a medium-pressure tank with 3.75 gal. capacity can handle a variety of corrosive materials or very pure water without contamination of tank or liquid.

A seamless plastic inner shell provides the corrosion resistance. It is supported by an outer shell of aluminum that gives the tank a bursting strength of 500 psi. Depending on the type of plastic used for the inner liner, operating temperatures from 185 to 225 F. may be realized.

Symmetrical at top and bottom, the tank has 4-in. end openings that are reduced with plastic fittings to ¾-in. No liquids come in contact with tank metal. Optional equipment: a molded two-piece insulation jacket.—**Bruner Corp., Milwaukee.** 62A

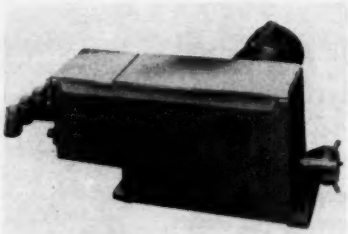
Continuous sampler

Unit floats on liquid, slowly samples over a long period.

How to get a continuous representative sample of tank or pond contents over an extended time period is a problem that is apparently solved by the Aquator, a device for slow and continuous sampling of liquid materials.

The unit consists of a collection chamber, a capillary tube and a float. When the device is lowered into water or other low-viscosity liquid, air is compressed within the collection chamber. As the air slowly bleeds out through the capillary tube, liquid is collected at a fixed rate to provide a representative sample.

Collection rate is approximately 2 qt. in 24 hr. (for water) in the 1-gal. collecting chamber. Sampling depth may be adjusted from 17 to 30 in. The unit is made of plastic except for a lead weight in the base, which is corrosion-proofed. A handle on top provides a means for getting it in or out of the liquid, and anchoring it in one spot if desired.—**Princeton Div., Div. of Curtiss-Wright Corp., Princeton, N. J.** 62B



Metering pump

Diaphragm or plunger types are controlled by new drive unit.

All parts of the drive that converts the high-speed rotary motion of the drive motor into the reciprocating motion of the pump plunger are submerged in an oil bath in this metering pump for liquid chemical feed systems.

Operating with either a leak-proof diaphragm or packed plunger liquid end, the unit can be used with electric or pneumatic controls for automatic feed systems. Metering accuracy is said to be ±1% or better.

Pump design permits 0 to 100% stroke adjustment while the pump is running. Approximately linear control is obtained by adjusting the stroke so that, regardless of setting, the plunger returns completely on the forward (discharge) movement.

Capacities range from 0.89 gal./hr. at up to 4,470 psi., to 88 gal./hr. at 170 psi.—**Milton Roy Co., Philadelphia.** 62C

Constant-rate feeder

Head-loss equalizer gives same flow rate despite liquid level.

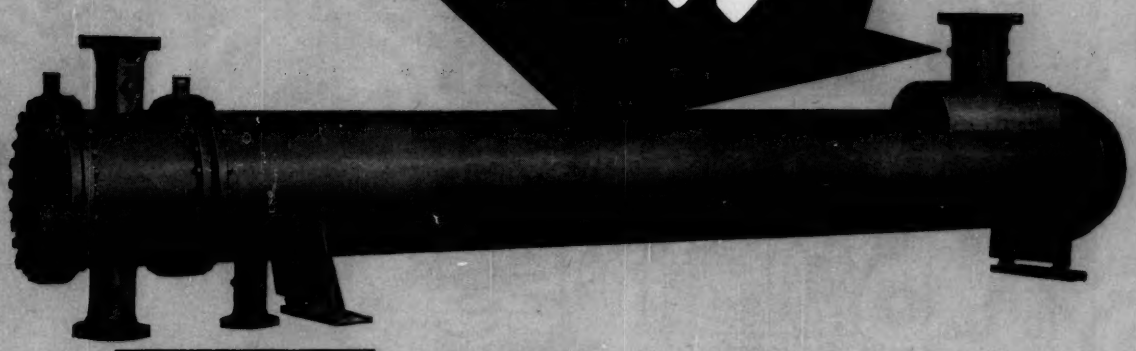
Do you want to meter a constant flow rate from a drum despite the change in height of the drum's contents? A newly designed feeder that incorporates a head-loss equalizer to offset descending liquid level is said to do the job. It handles any clear liquids contained by PVC.

One improvement over the original model: a calibrated control knob for easy viewing and quick return to a previous setting. And for more accurate flow rates, the new feeder is provided with an in-

More New Equipment continued on page 134

For more information about any item in this department, circle its code number on the Reader Service Postcard (Page 151)

NEW



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Outstanding Purchaser Advantages:

1. Proven construction reflecting many years experience in designing and fabricating custom shell and tube exchangers for the Petroleum, Petrochemical, Chemical and allied industries.

2. Elimination of custom engineering charges.

3. Less costly than custom designed exchangers, permitting a *smaller* appropriation to buy *more* plant facilities.

4. Certified final dimensioned drawings furnished with the quotation.

5. Approval of drawings given with the purchase order, minimizing drafting and transmittal time.

6. Piping layout and support structures can be started without delay.

7. Dome design and port location assure maximum operating efficiency.

8. Maximum tube counts by computer calculation minimize fluid by-pass.

9. Adequate inventories and partial pre-fabrication speed delivery.

10. Full compliance with ASME and TEMA-R Codes, whichever is most exacting, plus G-R quality control.

11. Wide range of shell sizes, surfaces, and pressures to meet all but the most unusual requirements.

12. Acceptable modifications from standard construction provide the flexibility of custom design in meeting individual specifications of large operators.

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Chromium Fluoride
Copper Fluoborate
Fluoboric Acid
Fluorinating Agents
Frosting Mixtures
Hydrofluoric Acid Anhydrous
Hydrofluoric Acid Aqueous
Hydrofluosilicic Acid
Laboratory Fluorine Cells
Lead Fluoborate
Lithium Fluoride
Metallic Fluoborates
Nickel Fluoborate
Potassium Bifluoride
Potassium Chromium Fluoride
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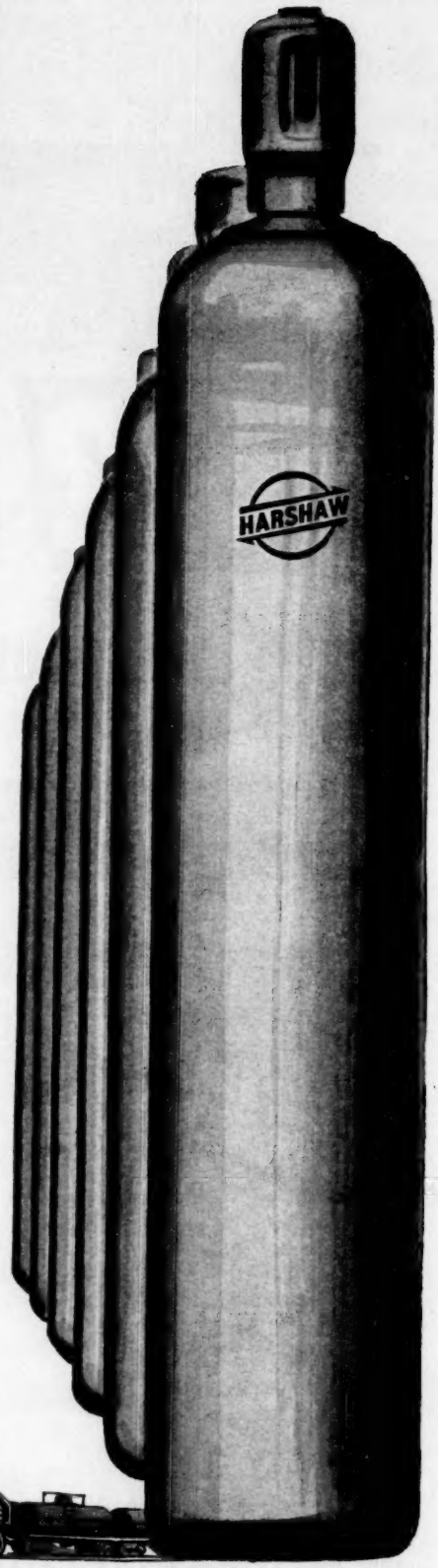

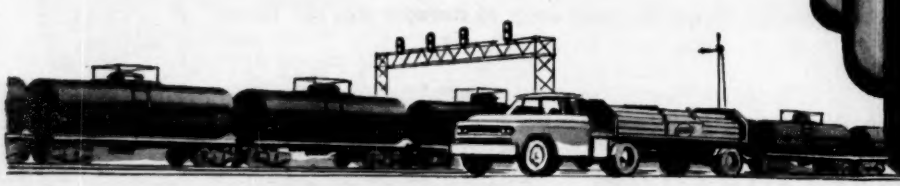

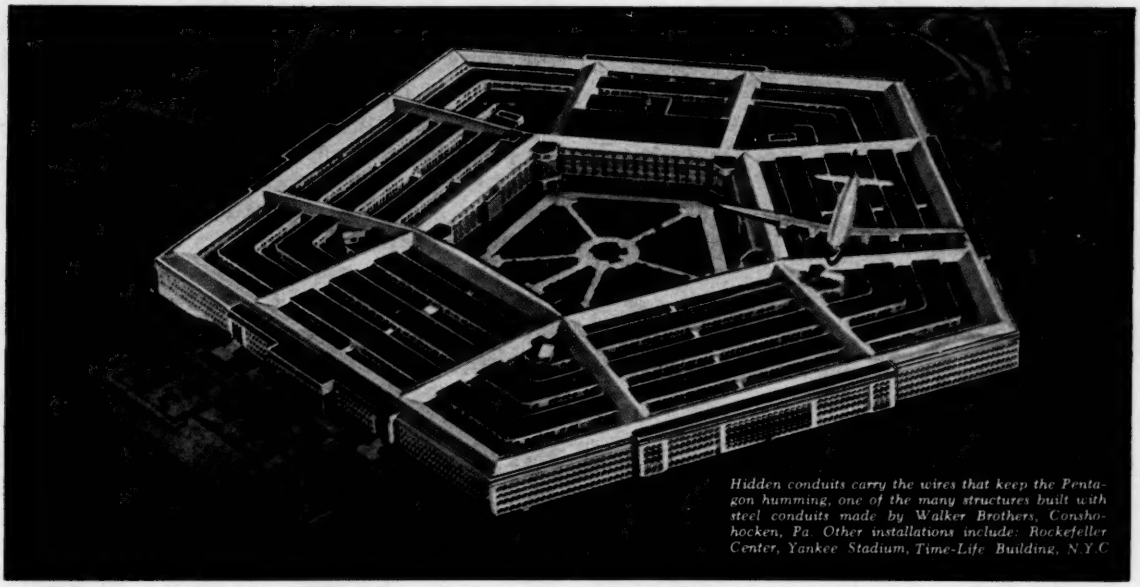

Hidden conduits carry the wires that keep the Pentagon humming, one of the many structures built with steel conduits made by Walker Brothers, Conshohocken, Pa. Other installations include: Rockefeller Center, Yankee Stadium, Time-Life Building, N.Y.C.

Sel-Rex Rectifier Helps Walker Brothers Meet Up-To-The Minute Delivery Schedules!!

The Pentagon, as with many modern structures, is honeycombed by thousands of Walker Brothers conduits and ducts that carry miles of telephone, dictaphone and low voltage electrical wiring.

Getting these tons of rigid steel conduit to the initial construction site calls for adherence to precise building schedules—timing deliveries to meet contractors' hoist schedules. Otherwise costly delays result; deadlines are disrupted.

Walker Brothers Conduit Division, Conshohocken, Pa., assures on-time deliveries with the help of a Sel-Rex Silicon Rectifier. It powers the plant's giant overhead cranes that lift, haul and load tons of steel every day.

The rectifier was chosen for a special reason: when the company's motor generator suffered a breakdown, a virtually complete production shutdown resulted. To prevent a recurrence, Walker selected a Sel-Rex Rectifier to supply its D.C. requirements . . . chosen because "it has no rotary parts to wear out, has low installation cost, negligible maintenance and low operating cost."

These statements from a Walker Brothers official make good sense. They are the same sound reasons why thousands of firms have chosen Sel-Rex Rectifiers as their modern, trouble-free source of dependable D.C. power.

Tons of steel conduit made at the Conshohocken, Pa. plant of Walker Brothers are carried by overhead cranes powered by a Sel-Rex Silicon Rectifier.

Send for Free "GUIDE" to Industrial Rectifier Equipment

THE MEAKER COMPANY

SUBSIDIARY OF SEL-REX CORPORATION

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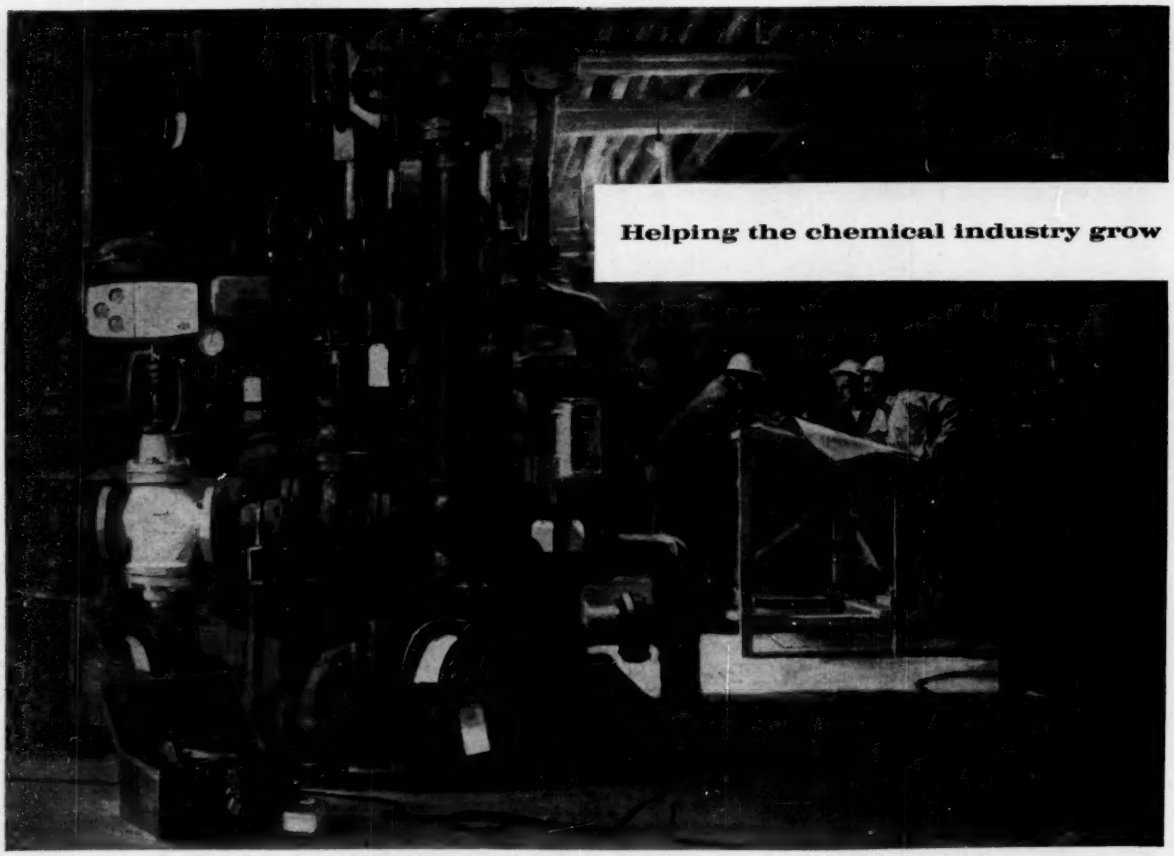
Complete Semi-Conductor Power Conversion Equipment and Systems for any AC to DC Application

Chemical pipe maze

Surrounded by an intricate complex of pipes and carefully tagged valves, fitters consult their blueprints for the next step toward completion of this modern chemical processing plant. For many years United Engineers has served America's fast-growing chemical industry on projects of widest scope and variety. Each project has demonstrated our ability to operate efficiently within a budget and on schedule. Our growing list of new clients, plus the many new assignments from those previously served, is proof of the confidence placed in us. For your next chemical processing project—as well as power plant, steel mill, industrial or utility installation—we invite you to profit from our background of over 75 years' experience as designers, construction engineers, and engineering consultants.

Painting by Robert Lavin



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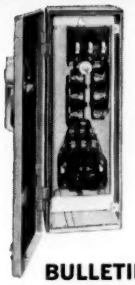
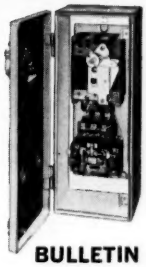
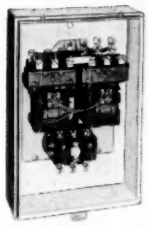


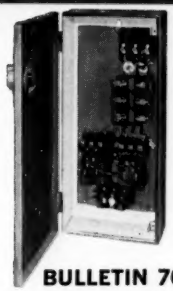
BULLETIN 712
Size 1 combination starter with fused disconnect switch



BULLETIN 713
Size 1 combination starter with circuit breaker

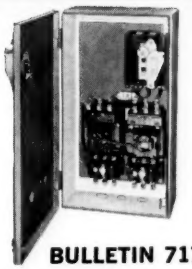


BULLETIN 705
Size 2 across-the-line reversing starter with overload relays



BULLETIN 706
Size 1 reversing starter with fused disconnect switch

BULLETIN 715
Size 1 across-the-line, multi-speed starter with overload relays



BULLETIN 717
Size 2 multi-speed starter with circuit breaker

BULLETIN 702
Size 3 three-pole, a-c solenoid contactor

Pygmies in Size Giants in Performance—

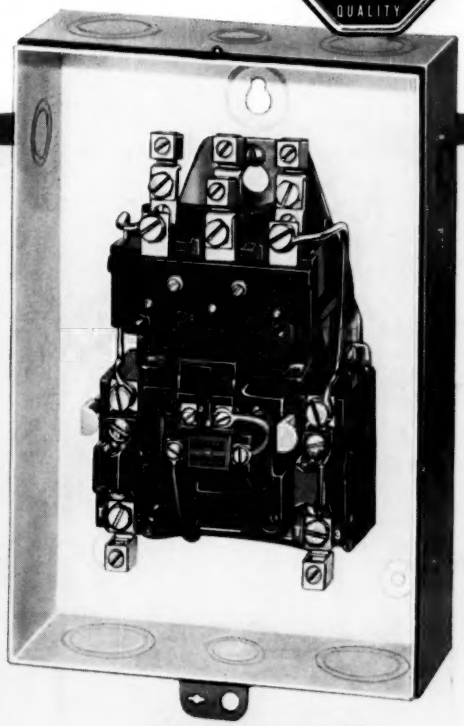
the NEW Allen-Bradley Across-the-Line Starters!

This new line of across-the-line motor starters is the result of over 30 years of experience and leadership in the motor control field.

While retaining the simple solenoid principle—with only ONE moving part—these starters are completely new in every way. They are amazingly small in size—yet test after test has proved they will not only outperform but also outlast any starter now on the market. They are good for *many millions* of trouble free operations. All have scores of design refinements that make them easier to install and maintain. All are available in the smart new enclosures designed by Brooks Stevens. They make a beautiful addition to any machine or control installation.

You'll want to get the complete story about these truly revolutionary new across-the-line starters. Write for new Publication 6100.

A-B QUALITY



BULLETIN 709

This popular across-the-line solenoid starter shows the new Size 2 construction. Note the white interior and generous wiring space. Bulletin 709 starters are available, in the new construction, in seven sizes—Sizes 00 to 5, with a maximum rating of 100 hp, 220 v; 200 hp, 440-550 v.

11-61-RM

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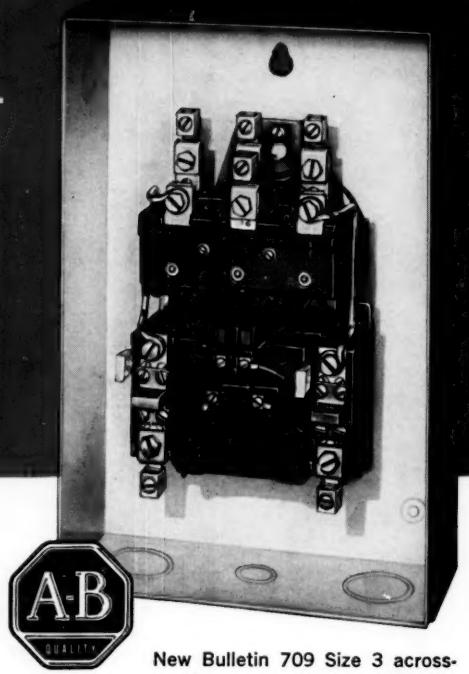
Member of NEMA

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.

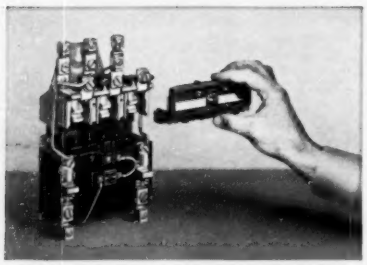
QUALITY MOTOR CONTROL

Features of the NEW Allen-Bradley starter line that are of value to you!

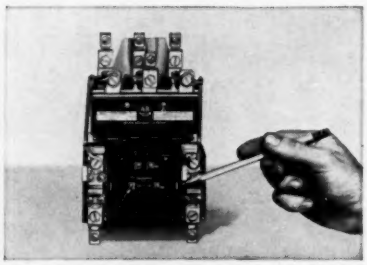


New Bulletin 709 Size 3 across-the-line motor starter. Note the generous space for wiring, accessible terminals, and white interior.

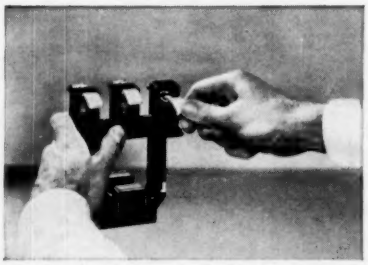
Every detail of the new Allen-Bradley motor starters has been designed to help make this the best line of motor control on the market. Remarkably small in size, each starter is a giant in performance. Being light in weight, these starters are easy to handle and a cinch to install. The generous wiring space, full front wiring, white interiors, and convenient knockouts make installation easy. The enclosure cover is firmly held with a quarter-turn fastener. All installation, inspection, and maintenance operations can be handled from the front—as shown in the illustrations below—without the use of special tools.



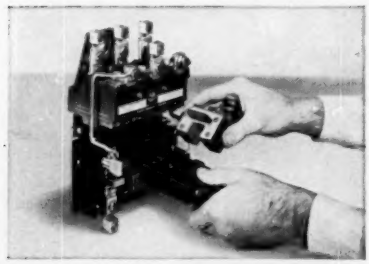
QUICK, EASY CONTACT INSPECTION—When the arc hood front cover is removed by loosening two captive screws, contacts are plainly visible from the front.



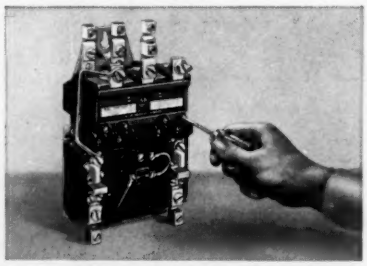
CONTACT POSITION INDICATED—Two slots in the coil cover show the position of the movable contact support—tell whether contacts are "closed" or "open."



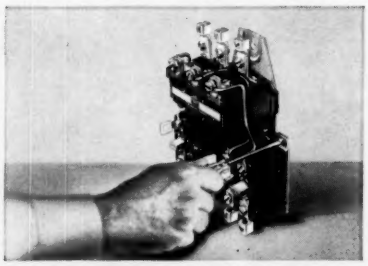
CONTACTS EASILY REPLACED—Depress the spring slightly, and the movable contacts can be lifted out of the molded support and the new contacts slipped in.



COIL EASILY CHANGED—When the coil cover is removed, coil and magnet yoke can be lifted out from the front. They are impossible to replace incorrectly.



AUXILIARY CONTACTS EASILY ADDED to the front of the starter. Two extra auxiliaries can be added to Sizes 0, 1, and 2 starters, and four, to Sizes 3, 4, and 5.



A THIRD OVERLOAD RELAY CAN BE EASILY ADDED in the field, from the front of the starter. And the only tool needed is a common screwdriver.

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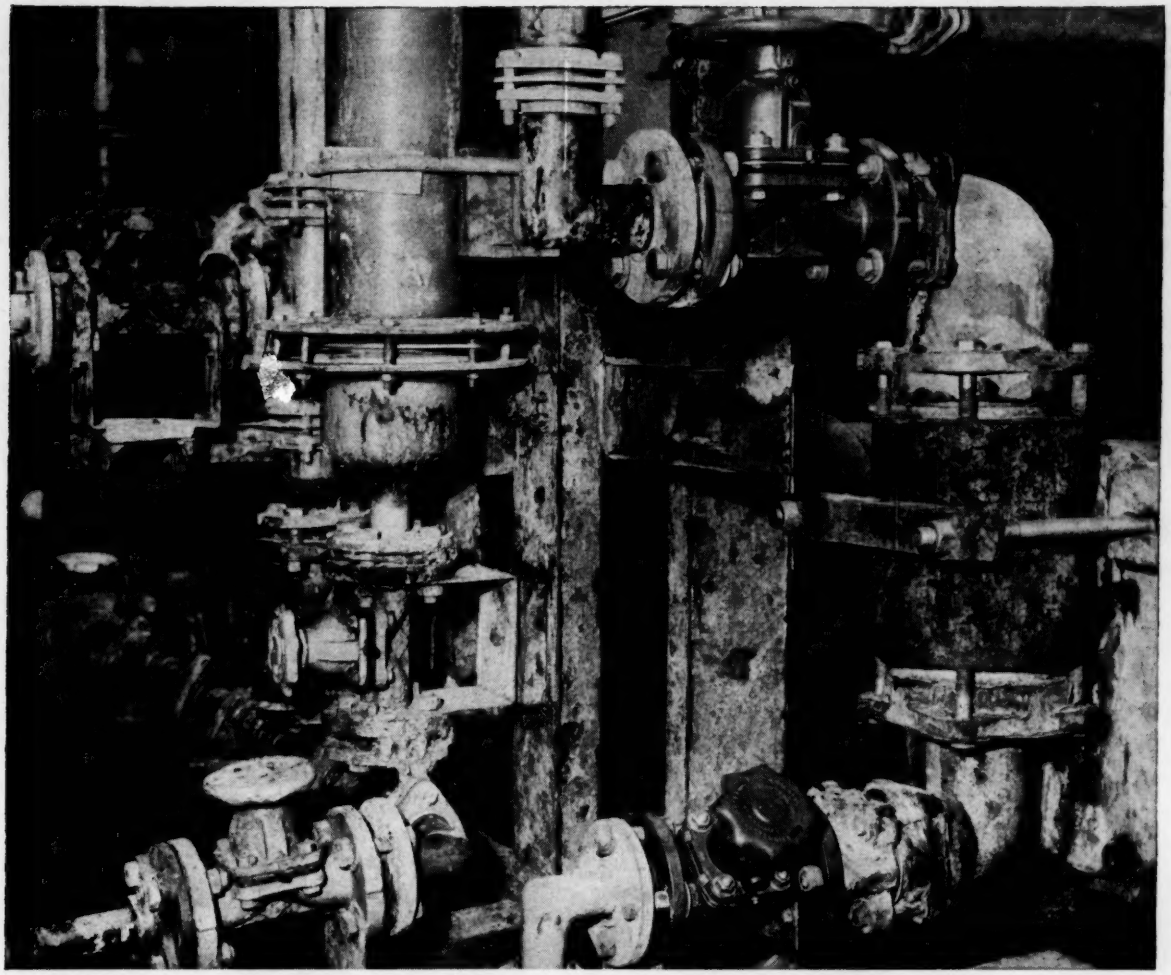

Encrustation on two of the above valves was cleaned off to show the lack of corrosion. Compare this with the corroded condition of the structural steel.

Carborundum has 200 Good Reasons For Using PENTON*

Two years ago Carborundum Metals Company Division installed 200 Grinnell-Saunders diaphragm valves at its plant in Parkersburg, West Virginia. All of these valves were protected, inside and outside, with a tough, durable coating of Penton. Their job in processing zirconium: handling highly corrosive caustic soda and sodium hypochlorite at 212°F., and methyl isobutyl ketone, hydrochloric acid and sulphuric acid at 130°F.

Today, Carborundum reports that all of these valves are still in service, without failure or replacement of parts. Two hundred good reasons for the growing reputation of Penton as an economical means of obtaining high temperature corrosion resistance in severe exposures.

Versatile Penton is now used in many forms for all types of chemical processing equipment including valves, pipe and fittings, pumps, meters, and lined or coated vessels. Penton can offer you important savings in original costs and maintenance, and in many instances will permit higher processing temperatures for increased yields. Ask your supplier for information on Penton components for your requirements, or call or write Hercules for your copy of "The Penton Buyer's Guide."

*Hercules registered trademark for chlorinated polyether.

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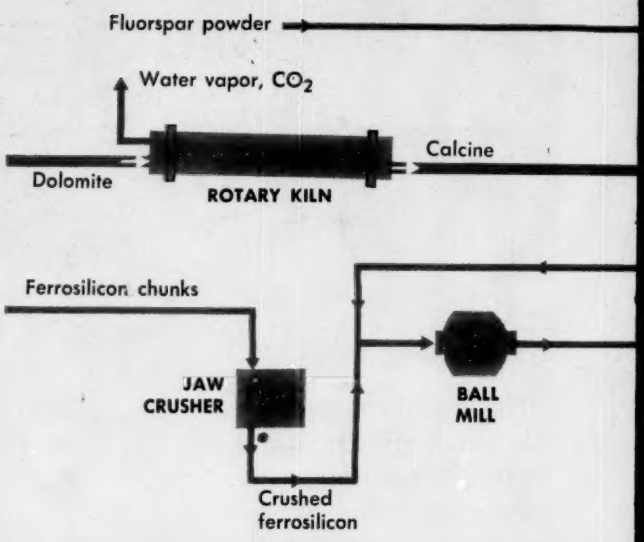
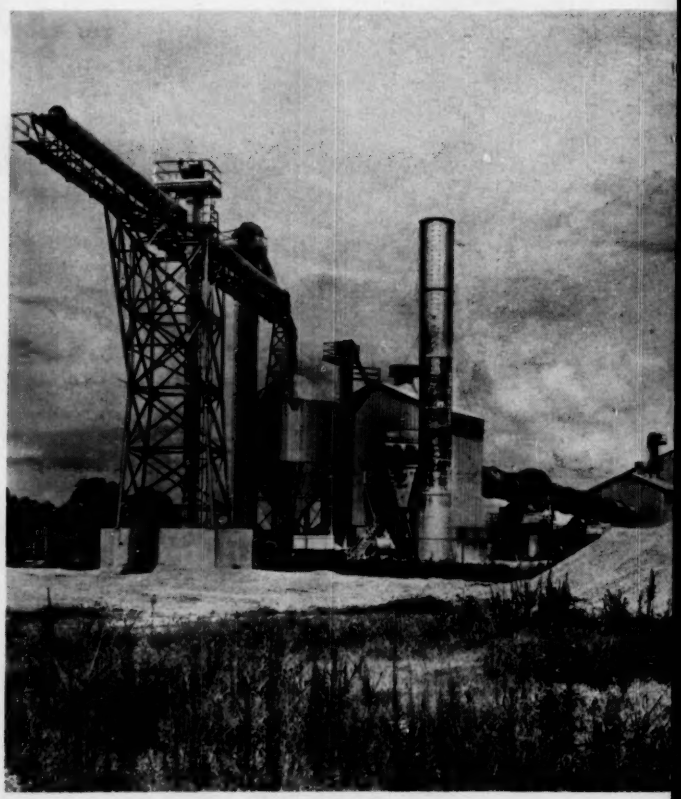


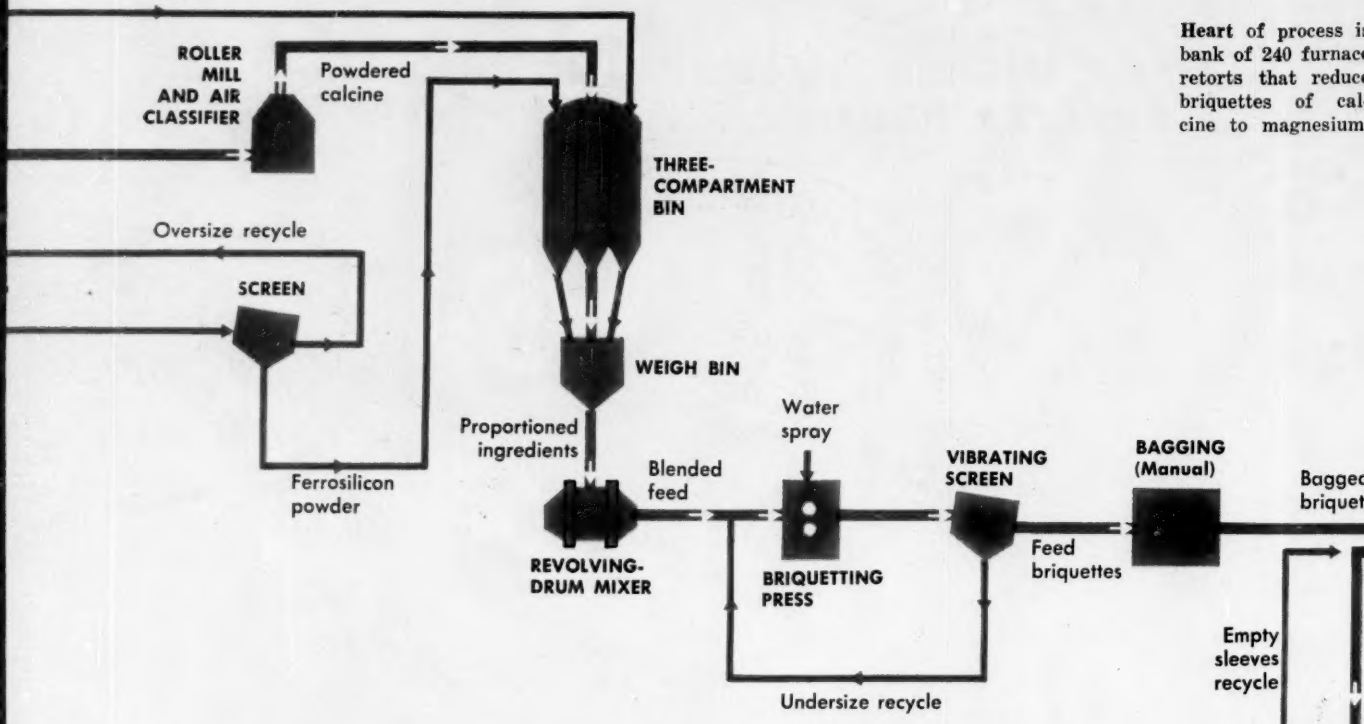
Magnesium Producer Shuns Electrolysis

Historically, electrolysis of brine-derived solutions has virtually dominated U. S. commercial magnesium manufacture. But Alabama Metallurgical Corp. dusted off a thermal process previously used only during national emergencies and, with a plant at Selma, Ala., has been a market competitor since late 1959.

B. E. BARNES
McGraw-Hill World News: Atlanta



Basic raw material, dolomite ore, is calcined to magnesium and calcium oxides in rotary kiln.



Heart of process i
bank of 240 furnac
retorts that reduc
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cine to magnesium

Alabama Metallurgical Corp.'s first magnesium delivery from its new 6,000-ton/yr. plant at Selma, Ala., some 18 months ago, had significance well out of proportion to the size of either the plant or the shipment.

Reason: the facility represents the first commercial operation by a U. S. firm to produce magnesium by other than electrolytic means. With its Selma manufacture, based on thermal reduction of dolomite ore, the company has ventured into a commercial picture dominated by one producer—Dow Chemical Co.—and one process: electrolysis of magnesium chloride obtained by treating brine.

Manufacturing procedure used at Selma is not new. Known as the Pidgeon process, it came into its own during World War II when magnesium was a strategic material. In summary, process consists of calcining dolomite ore—a magnesium-bearing limestone characterized by the formula $CaMg(CO_3)_2$—and combining the calcine with ferrosilicon reducing agent and fluorspar. Mixture goes to a reducing furnace that yields the product metal, which has been described as purer than magnesium produced by electrolysis.

Several government plants employed the Pidgeon route during the early 1940's but these facilities were shut down upon return to peacetime conditions. Since then, they have been operated only during the Korean War period.

Alabama Metallurgical was organized in 1956 by Brooks & Perkins, Inc., Detroit, and Canada's Dominion Magnesium Ltd., because improvements in magnesium alloying and fabricating technology suggested that the time was ripe for a new commercial producer to enter the industry.

Dominion Magnesium, possessor of Pidgeon process know-how, subsequently sold its interest to Brooks & Perkins. Following a recapitalization of the new company in 1958, the latter firm now owns 30% of Alabama Metallurgical and the balance is owned by Calumet & Hecla, Inc.

▶**Viewing the Process**—In the past, industry opinion has generally held that electrolysis of brine-derived solutions—as typified by Dow's operations—is the most economical route to magnesium. However, Alabama Metallurgical management points out that refinements in equipment selection throughout the steps of the Pidgeon process permit the company to compete successfully with Dow.

The Selma plant receives dolomite ore as ½- to 1-in. chunks. Material passes through a rotary kiln operating at over 2,000 F., which drives off moisture and carbon dioxide, and converts the carbonates to calcium and magnesium oxides.

A roller mill grinds the calcine to a −200-mesh powder, which is blown into one section of a three-compartment storage bin.

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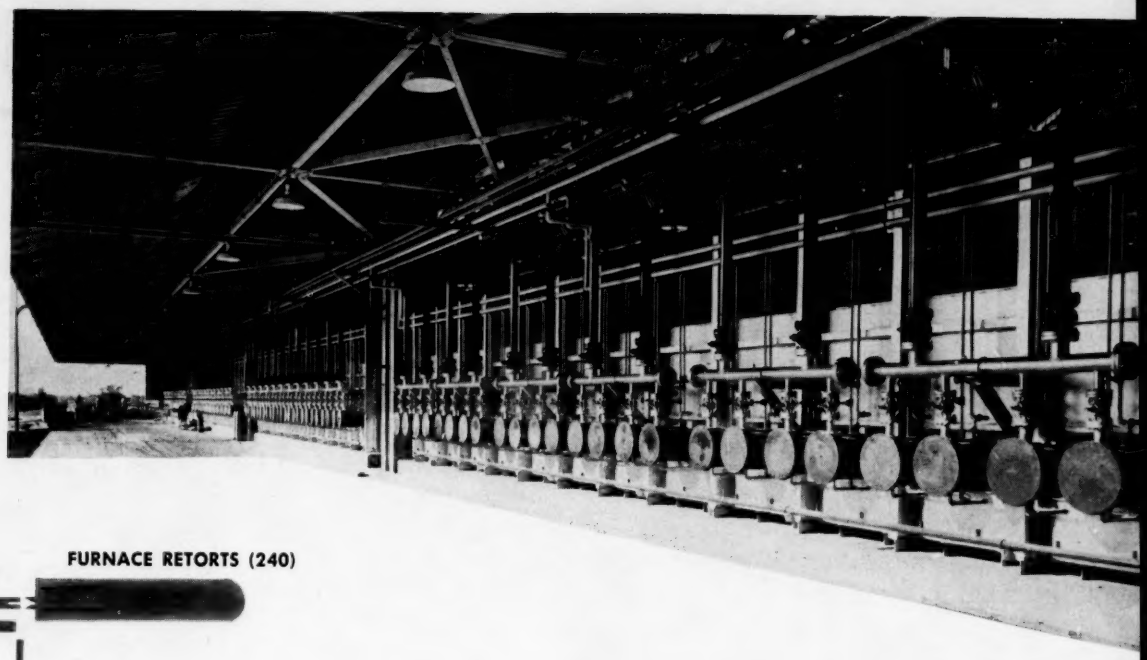

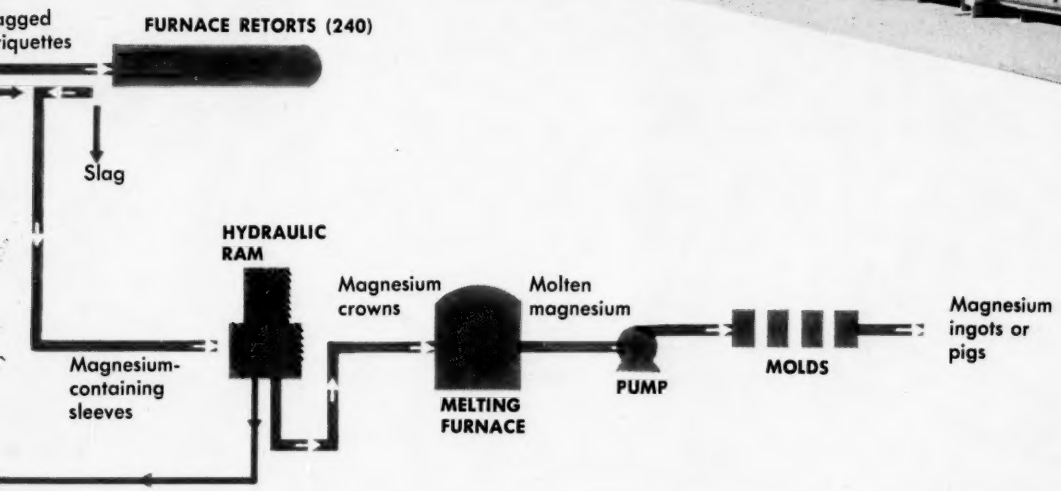

Meanwhile, chunk ferrosilicon of 75% grade
s through a jaw crusher that yields —1-in.
uct. Latter is ground in a ball mill and the
er goes to the storage bin. Fluorspar is
nased as a 300-mesh powder and is routed
tly to storage.

A revolving-drum mixer blends the three
dients and the mixture goes to a briquetting
. Briquettes formed pass over a vibrating
n, then on to a manual operation where they
laced in 50-lb. paper bags.

The filled bags are ready to enter the reduc-
furnaces. Reasons for bagging are to facili-
handling and prevent furnace arch action.

luction—Plant has 10 gas-fired reduction
ces, each consisting of 24 horizontal stain-
steel retorts that measure 10 in. in dia. and
long. They house the reducing reaction:

$$2CaO \cdot MgO + Si(Fe) \rightarrow 2Mg + Ca_2SiO_4(Fe)$$

feed end of each retort is provided with an
nal water jacket for cooling.

About 300 lb. of briquettes is charged to each retort, bags and all. Condensing sleeves are then inserted into the feed ends, and the retorts are sealed and evacuated to about 50 microns. This high vacuum permits magnesium to vaporize at comparatively low temperature, protects the vapor from effects of oxygen or nitrogen.

Furnaces operate around 2,150 F., and reduction is carried out for about 8 hr. Each retort yields 48 lb. magnesium, corresponding to 85% of the amount available.

▶ **Final Steps**—Magnesium is deposited on the condensing sleeves, forming crown-shaped pieces of metal. After reduction is completed, the sleeves are removed and byproduct slag is emptied.

Magnesium-containing sleeves go to a hydraulic ram that forces the crowns free. Latter are remelted in a gas-fired furnace, and the molten metal is routed by a stainless steel centrifugal pump to molds for production of either 20-lb. ingots or 40-lb. pigs.

Nash Compressors Tame "Hard-to-handle" Corrosive Gases

The reasons for the success of Nash Compressors in handling "dirty" and corrosive gases are simple. First, Nash Compressors have no internal parts in wearing contact, or requiring close tolerances and internal lubrication. Second, because of the Nash operating principle, a variety of liquids can be employed as the compressant medium, protecting the interior from corrosive action. Third, the pump casing may be fabricated from a variety of special metals and alloys. That is why Nash Compressors take these rugged jobs in stride.

Nash Vacuum Pumps offer the same basic advantages when handling corrosive gases, and reliably maintain vacuums up to 29.50 inches of mercury.

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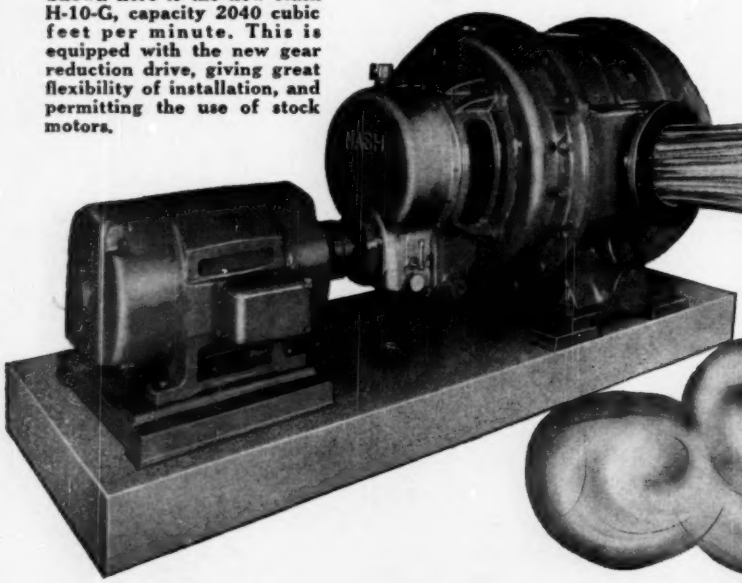
AMMONIA
ARGON
BUTADIENE
CARBON DIOXIDE
CARBON MONOXIDE
CHLORINE
ETHYL CHLORIDE
FLUE GAS
FURFURAL
HEXANE
HELIUM
HYDROGEN
HYDROGEN SULPHIDE
NITROGEN
OXYGEN
PHOSPHOROUS PENTOXIDE
SULPHUR GAS
VINYL ACETATE
VINYL CHLORIDE
AND MANY OTHERS

Shown here is the new Nash H-10-G, capacity 2040 cubic feet per minute. This is equipped with the new gear reduction drive, giving great flexibility of installation, and permitting the use of stock motors.



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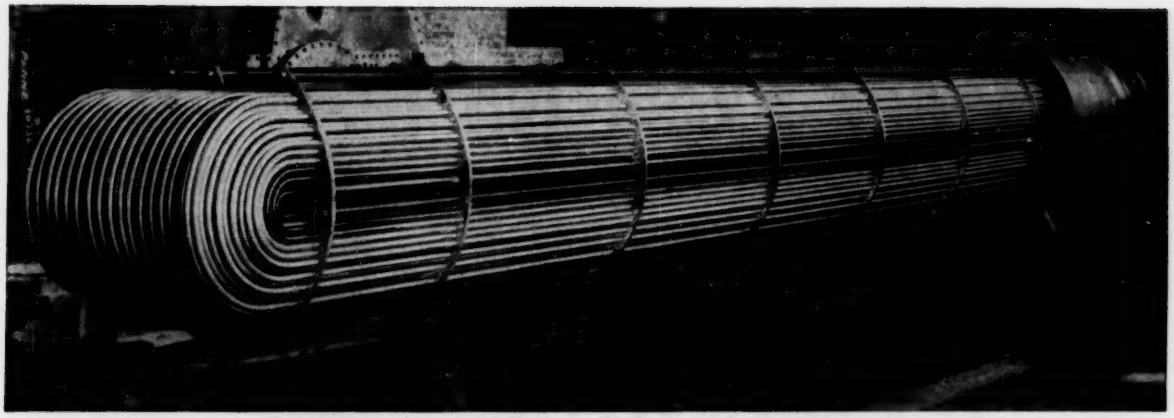

This typical bundle of long-length Anaconda U-Bend tube is the heart of the modern feedwater heater. To get optimum capacity and efficiency—and a more economical and compact unit—designers have lengthened heaters instead of increasing shell diameter.

IN POWER PLANT FEEDWATER HEATERS

Anaconda long-length U-bend tubes offer higher efficiency and greater economy

Feedwater heaters play an important role in the efficient operation of a steam power station—and with today's more demanding conditions, the trend is to the use of long-length U-bend tube bundles in these higher pressure, higher temperature heat exchangers.

U-bend tube design reduces the number of tube joints to one-half. Each U-bend tube takes care of its own expansion stresses. There's no floating head—one less gasketed joint—all resulting in a more economical, more compact heater.

Now Anaconda makes heat exchanger tubes to 100 feet. This means U-bend tubes with legs approaching 50 feet are available. And the radius of the bend can be as small as 1½ times the diameter of the tube—or as great as 30 inches. Dual-gage tubes are made with extra wall thickness in the area of the bends, to cut cost and weight.

With a large family of alloys available for heat exchanger tubes, Anaconda can meet almost every requirement. From Arsenical Admiralty-439 to the cupro nickel group, long-length U-bend tubes can be made to handle a wide range of temperatures and pressures.

Specialists at Anaconda are constantly working with users and manufacturers of heat exchange equipment, helping to solve individual problems. This experience is available to you. For more detailed information on duplex tubes, dual-gage as well as U-bend tubes, see your Anaconda representative. Or write to: Anaconda American Brass Company, Buffalo Division, Buffalo 5, New York. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario. 6061

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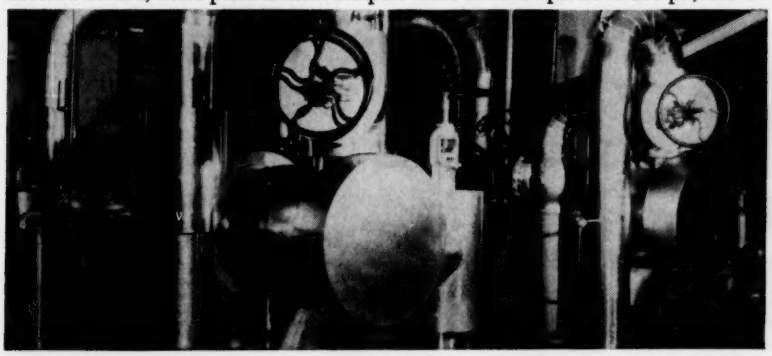
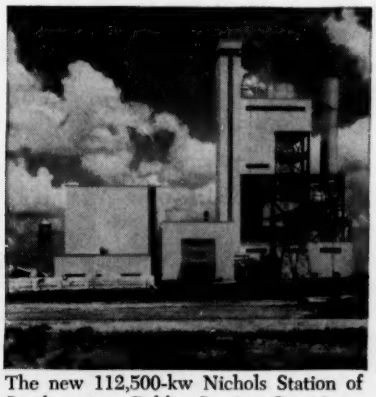
Anaconda American Brass Company

Two of the three feedwater heaters at Nichols Station, using a total of 1692 Anaconda U-bend tubes of Arsenical Admiralty-439. Griscom-Russell Co., Massilon, Ohio, designed and built the heaters. U-bend bundles of longer, smaller diameter tubes provide a more effective surface, make possible more compact units. Heaters operate at 200 psi, 450°F.

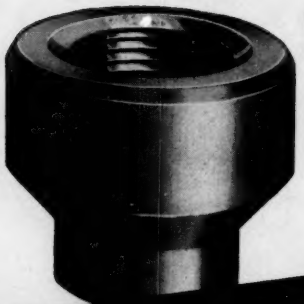




The new 112,500-kw Nichols Station of Southwestern Public Service Co., Amarillo, Texas.

Another* Exclusive Vogt Product

FORGED STEEL WELD COUPLETS

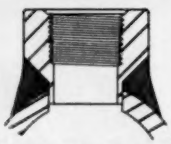


THREADED TYPE

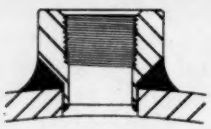
SOCKET WELD TYPE

*with Exclusive Vogt "WELD RING"

The Vogt Weld Couplet is an easy-to-install fitting for branch connections from pipe, vessels or tanks. It replaces more-difficult-to-install welding bosses, couplings and the type of fittings requiring trimming or matching to fit contour of vessel or pipe.



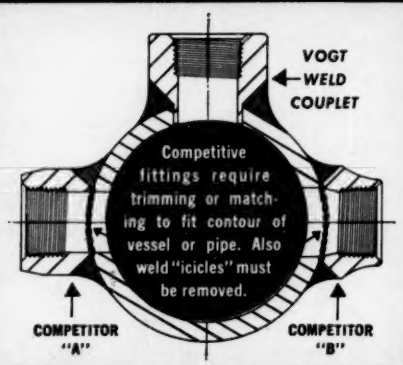
Small Diameter Pipe



Large Diameter Vessel

Vogt Weld Couplets adapt to any pipe or vessel curvature by simply adjusting the height position of the couplet when welding. This characteristic means easy installation, positive positioning and alignment, a stronger weld without distortion, and no inside "icicles" of welding material.

Couplets are available in carbon steel, conforming to A.S.T.M. specifications. Other materials can be supplied on special order.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Competitive fittings require trimming or matching to fit contour of vessel or pipe. Also weld "icicles" must be removed.
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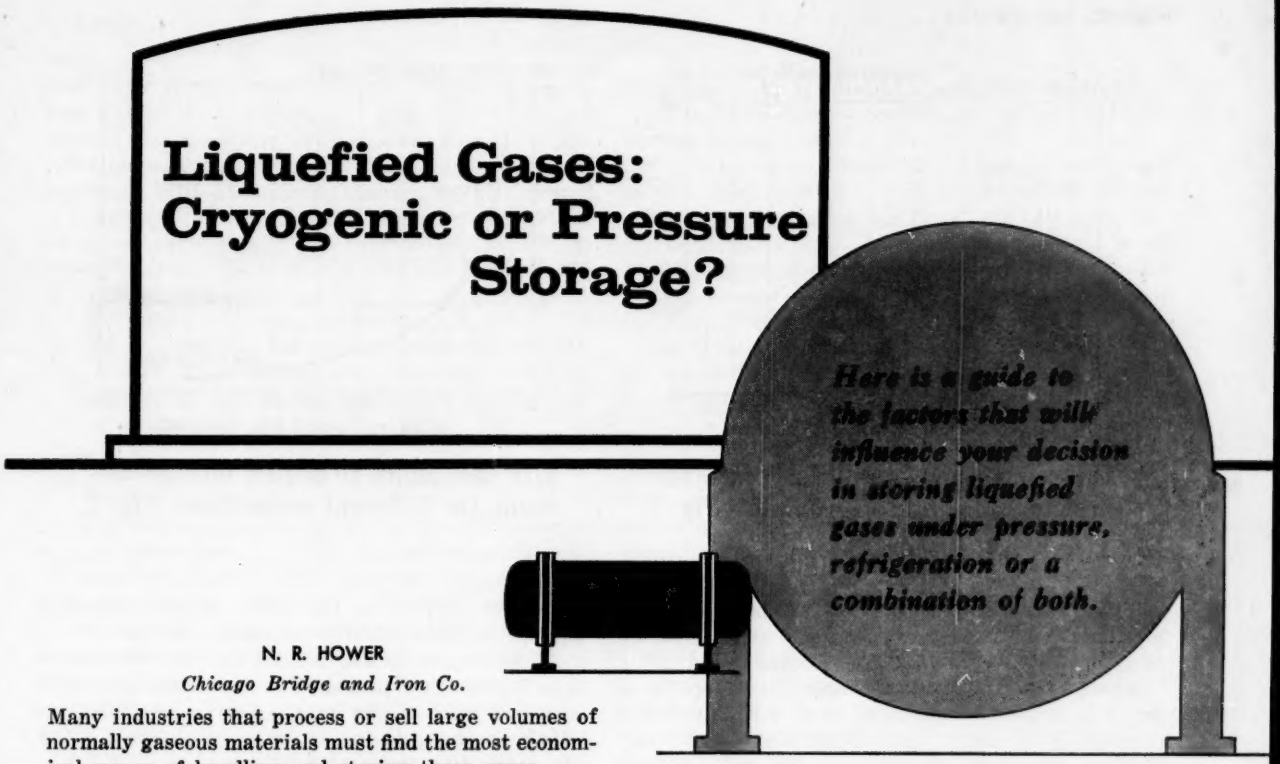
Liquefied Gases: Cryogenic or Pressure Storage?


Here is a guide to the factors that will influence your decision in storing liquefied gases under pressure, refrigeration or a combination of both.

N. R. HOWER
Chicago Bridge and Iron Co.

Many industries that process or sell large volumes of normally gaseous materials must find the most economical means of handling and storing these gases.

There is no longer much doubt that the best way to deal with a large volume of gas is to liquefy it. This is obvious when we consider that 250,000 cu. ft. of household heating gas, enough to fill a tank the size of a six-story building, can be held in a large tank truck when liquefied. However, many common gases, such as butane, propane, butadiene, ammonia, oxygen, Freon, etc., can be liquefied with almost equal ease by either pressure or refrigeration. Propane, for example, is a liquid at ambient temperature and a pressure of 200 psig.—but it is also liquid at −45 F. and atmospheric pressure.

The problem, then, is whether to adopt pressure, refrigeration or a combination of both to reduce gases to the liquid state. As we shall see, the answer depends on a number of factors such as volume handled, frequency of receipt, frequency of shipment and method of receipt or shipment.

Storage is an essential part of gathering gases for shipment and stockpiling them upon delivery. Original supply, periods of transportation and end use may all be seasonable without respect to each other. This imbalance calls for large gathering terminals at the source, capable of receiving small continuous increments of input, and of discharging large quantities to tankers on short notice. Similarly, receiving terminals may have to accommodate a heavy seasonal demand of off-season deliveries at a lesser rate. Flexibility, therefore, is of utmost importance.

Case Study for a Typical Propane Facility

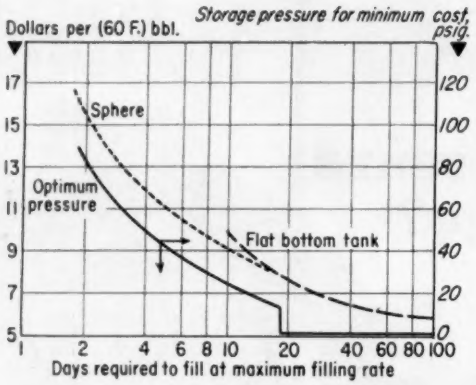
In a paper entitled "Liquefied Petroleum Gas Storage in Above Ground Metal Tanks," John T. Horton presented a case study for the storage and handling of 20,000 bbl. of propane. This study can be applied to other volumes and other products if adjusted for changes in physical characteristics.

Fig. 1, which is taken from this paper, is a plot of the cost/bbl. of storage and related refrigeration equipment, based upon the ratio of container capacity to maximum daily rate of product receipt.

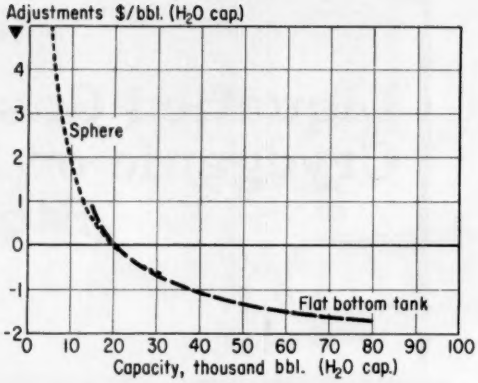
Installed cost of refrigeration equipment rises directly with the rate of daily throughput, and the temperature change imposed upon the product handled. Storage costs are constant for a given capacity and pressure, but increase as pressure rises and decrease as volume rises. When the ratio of tank volume to daily throughput is greater than 18, the most economical selection is flat-bottom tanks designed for slightly over atmospheric pressure. As this ratio decreases, pressure storage combined with limited refrigeration is indicated, to accomplish a smaller temperature change.

It is worth noting that the case presented here is a simple one based on hypothetical conditions seldom obtained. A study of a given situation may lead to a combination of both pressure and atmospheric storage in conjunction with refrigeration equipment scheduled for two separate operating rates. The following discussion will bring out some of the factors involved.

In the case of a large utility, we would probably be dealing with liquefied natural gas taken from a pipeline and stored by the hundreds of thousands of barrels. This gas would be withdrawn over a period of


Dollars per (60 F.) bbl.
Storage pressure for minimum cost, psig.
Sphere
Optimum pressure
Flat bottom tank
Days required to fill at maximum filling rate

This chart shows capital costs for storing 20,000 bbl. of propane—Fig. 1



Use this chart to adjust unit investment for different capacities—Fig. 2

200 days when surplus gas was available from the pipeline. For illustrative purposes and simplicity, however, we will consider a case adapted to Fig. 1.

Assume that propane is available from a pipeline as liquid at ground temperature or as gas at sufficient pressure to be readily liquefied and that we are interested in storing 80,000 bbl. over 200 days. This is equivalent to an incoming rate of 20,000 bbl. in 50 days. Reading the chart at the 50-day ordinate shows that the optimum pressure for minimum installation cost is approximately atmospheric.

A tank for this service would be built to withstand 1 psig. internal pressure, largely for convenience in operation. Again from the chart, we find that the unit cost per bbl. for combined storage and refrigeration is $6.25.

If it were desirable to build this installation in small increments, we would start with a refrigerating plant able to handle 400 bbl./day and one 20,000-bbl. tank. These could then be supplemented with additional 20,000-bbl. tanks as needed. Unit cost per bbl. would decrease, however, if a larger storage unit of 80,000 bbl. were built as the initial investment.

With installations of this nature, equipment is needed to return the liquid to the gaseous state at the demand rate. This equipment could be a product heater or there could be regulated release of the liquid into pressure storage where its temperature could rise slowly to a usable level.

Another problem is the evolution of gas in the refrigerated tank, caused by heat leakage. A necessary part of the installation, therefore, is a small extra refrigerating capacity for continuous reliquefaction of the evolved gases. In a properly constructed and insulated tank, the daily turnover is limited to less than ¼% of total capacity. Fig. 3 is a typical flowsheet for a small installation of this nature.

Let us now assume a situation in which gas is available in large quantities but only on a few days of the year. This might occur where a utility has a heavy industrial load during the warm months and intermittent service in the colder months, allowing transfer of the demand to household heating.

As before, let us also assume that it is desired to store 80,000 bbl. of propane that is available only on 50 scattered days of the year. This is equivalent to 20,000 bbl. received in 12½ days—which poses a new and interesting series of solutions.

If we evaluate this situation from Fig. 1 in the same manner as the previous example, we find that the optimum pressure for storing this rate of receipt is 20 psig., calling for a spherical tank. The upper curve gives a unit installation cost of $8.60 per bbl.

This solution ignores an important aspect of the problem—although the product is received at the rate of 400 bbl./day for short periods, there are lapses of time between the periods of receipt.

Let us assume that the gas becomes available on weekends, holidays, vacation periods or during periods of low demand in the consuming industry or process. Let us further assume that gas is received for periods of one or two days but that at least one week elapses between periods of receipt.

The economical solution in this case would be one in which we build a 20,000-bbl. or smaller pressure receiver with associated refrigeration capacity, in order to reduce the gas only a portion of the change from its received condition to its ultimate storage temperature and pressure, at a high daily transfer rate. The installation would then be completed with a large atmospheric-pressure storage tank having the total desired capacity. The same refrigeration equipment would suffice to further reduce the liquid, from pressure storage to atmospheric, at a slower daily rate.

Another common situation is one in which the product is delivered by tank car or truck. Unloading from such equipment is generally done during the day because this operation cannot be left unattended and because demurrage charges require that unloading be accomplished as quickly as possible.

Here we have a case where the rate of transfer is three times as great in 8 hr. as the rate at which

product would be further processed and transferred to final storage on a 24-hr. basis. Economic installation dictates that an increment of pressure storage be provided to receive the 8-hr. receipts directly from the transport. With a smaller refrigeration system geared to transfer at a 24-hr. rate, the warm liquid can then be moved automatically and continuously to a large atmospheric storage tank at a minimum cost per bbl. of installed capacity.

Fig. 1, along with the adjustment chart, Fig. 2, can be used to synthesize any given arrangement of pressure or atmospheric storage with associated refrigeration equipment, to suit any given ratio of volume to rate of transfer.

Storage Tanks Assume Different Shapes

Tanks for atmospheric storage of liquefied gases at temperatures down to −300 F. are generally constructed in the form of flat-bottom cylinders with self-supporting dome roofs. To provide insulation, a second tank of similar shape completely surrounds the liquid container. Granular insulation is installed between the two tanks (see Fig. 4).

Insulation between the two tank bottoms takes the form of rigid load-bearing blocks. The remainder of the space is filled with granular insulation that can flow for installation or removal.

It is worth noting that, in an installation of this nature, the insulation space is completely sealed against the outside atmosphere, and the outer steel shell protects the insulation from deterioration. The insulation space is usually blanketed with inert gas to maintain a nonexplosive atmosphere, to exclude air infiltration and to protect both outer and inner tank surfaces from atmospheric corrosion.

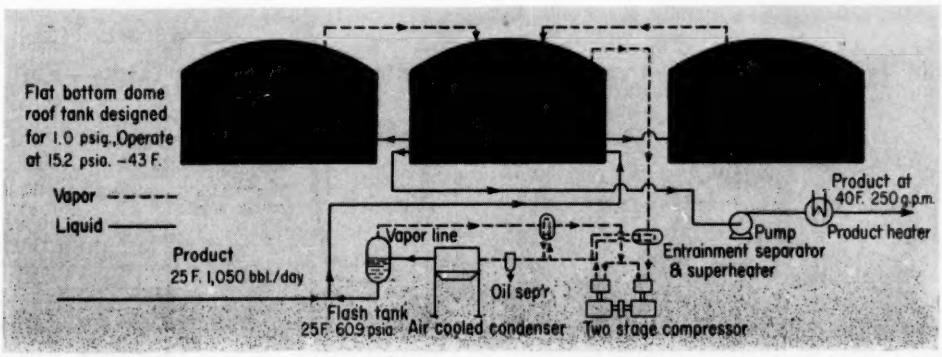
A significant factor in the design of flat-bottom tanks is configuration of the foundation. Where bearing value of the soil is high, the foundation can consist of a concrete ring wall, concentric with the axis of the tanks and filled to a chosen depth with well-graded sand and gravel. Immediately under the outer tank casing, there should be a source of heat, thermostatically controlled, to prevent the subsoil freezing from the constant transfer of heat from the earth into the tank.

Where bearing value of the soil is low—or the tank is very high, with unit loads exceeding soil bearing values—the foundation can be a slab held some feet above normal ground level on piling. This is an expensive form of construction but has the advantage, in this service, of providing air circulation beneath the tank, thus preventing freezing of the soil.

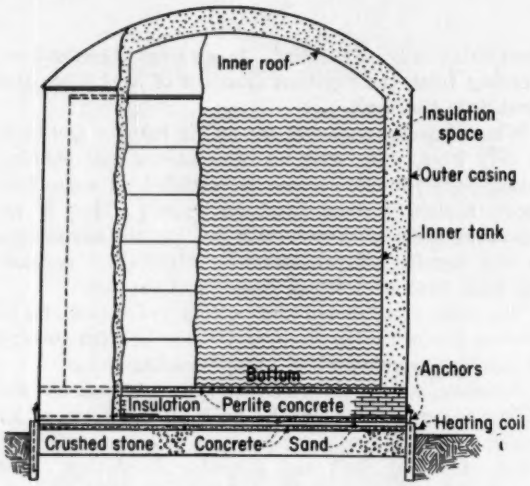
We have constructed flat-bottom cylindrical tanks all over the world, in sizes up 130,000 bbl. for storage of propane, ammonia and other liquefied gases.

Another equally serviceable type of tank is the Hortonsphere, which can be built in the form of an inner sphere for product storage, surrounded by an outer spherical shell and granular insulation. The sphere has many advantages that frequently result in lower installed cost than an equivalent flat-bottom cylindrical tank. These include:

- Enough pressure to overcome line friction for the evolved gases when the storage area is remote from the refrigeration equipment.
- Enough elevation to allow gravity discharge where desirable.
- A less-complicated foundation construction because subsoil freezing is not a factor. Piles can be arranged for maximum capacity and minimum number.
- Adaptibility to accepted code standards that are recognized by practically all municipal, state and insurance regulatory bodies.
- Minimum surface-area-to-volume ratio. Insulation volume and surface area available for heat leak in a sphere are 88% of the corresponding values in a flat-bottom tank of equal capacity. This leads to savings in both initial and operating costs.
- A supporting system that does not include the insulation between the spheres. Accordingly, the insulation can be removed at will to permit inspection and repair of the shells.
- Easy determination of the stresses induced under low temperature conditions. Although there



A typical flowsheet showing gas reliquefaction system—Fig. 3



Cutaway view of flat-bottom tank—Fig. 4

are no structural weaknesses from these stresses in flat-bottom cylinders, the stresses are of lesser consequence to the stability of spheres.

Because of these advantages, spheres have found wide acceptance in cryogenic storage applications. There are approximately 50 field-erected spherical installations in the U. S., ranging in size up to 30,000 bbl. and in temperature from −50 F. down to −423 F. These installations have conclusively proved their economic justification and structural adequacy.

Fig. 5 shows two typical sphere arrangements, as well as two other types of cryogenic storage vessel.

Added Safety From Storage as Liquid

Convincing evidence is available to show that liquefied gas at low pressure is safer to store and handle than equivalent quantities of gasoline or energy fuels commonly stored in public areas.

Vapor losses are the usual source of fire and explosion hazard around an average petroleum tank farm. Displaced gases are vented to the atmosphere, except in rare cases where product value warrants recapture. And daily temperature and barometric pressure changes cause air to be drawn into the tanks.

In a properly built liquefied gas installation, however, no vapors are vented to the atmosphere, except in emergencies. The volume of evolved gas does not exceed ¼% of tank volume and no air can enter.

In case of fire or explosion adjacent to an ordinary steel tank, the contents are exposed to great heat and there is danger of tank rupture. Not so with a double-walled insulated tank—the outer shell and the thickness of insulation protect the contents from explosion fragments, and heat exposure is slow and controlled.

Relief valves are chosen so that the gases evolved during a continuing fire, subjecting the outer shell to temperatures of 1,000 deg., can be vented without pressure rise dangerous to the structure.

A large tank of liquid propane at atmospheric pressure and a correspondingly low temperature would not vent for approximately 12 hr. in the event of failure in the recycle refrigeration equipment.

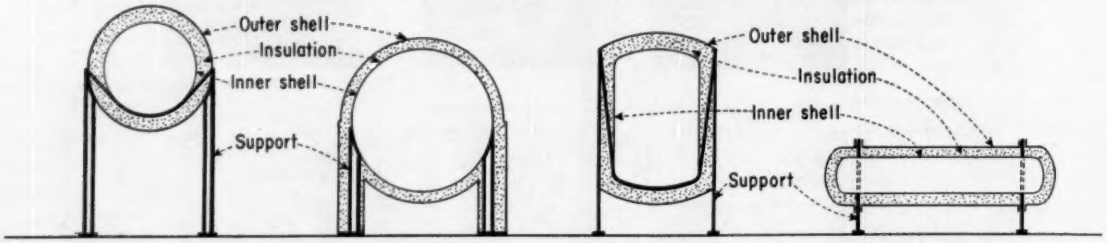
In the unlikely event of a rupture in both inner and outer shells, the liquid contents would be retained within a fire wall. It is actually difficult to maintain combustion at the surface of low-temperature liquefied gas. The evaporation rate is limited because the liquid contains little available energy, and heat must come from the earth or surrounding air.

When combustion is finally established, the energy release and extent of combustion is approximately one-fourth that of an equivalent surface of gasoline or other volatile liquid at ambient temperature.

Meet the Author

N. R. HOWER *is a contracting engineer with Chicago Bridge and Iron Co. Specializing in design and sales of products for atomic energy and cryogenic storage, he has been with CB&I for a total of 26 years in a variety of assignments in sales and operations and has been in his present position for ten years. Hower is a B.S.C.E. graduate of the University of Alabama (1936) and is a registered PE in that state and in N. J. He spent three years in the central Pacific during World War II as a member of a naval construction battalion.*

Four typical combination refrigeration- and pressure-storage tanks—Fig. 5



Small sphere suspended from legs | Large sphere resting on legs | Vertical dished-head tank | Horizontal dished-head tank

Designing Temperature Stable Reactors

Part II

(See *Chem. Eng.*, May 15, 1961, p. 165 for Part I on design of tubular reactors.)

Temperature Stability in Packed-Bed and Stirred Tank Reactors

During an exothermic reaction, an uncontrolled temperature rise may result from a slight change in conditions. Here's how to predict when a reactor will be stable.

PETER HARRIOTT,
Associate Professor, Cornell University

Packed Bed Reactors

Design of packed bed reactors is similar to that of tubular reactors, but temperature gradients complicate matters.

The design of packed bed reactors is more complex than that of homogeneous tubular reactors (*Chem. Eng.*, May 15, 1961, p. 165) because of radial temperature gradients in the packed bed.

With an exothermic reaction, the temperature profile is approximately parabolic near the center of the bed, and there is a sharp temperature drop at the wall through the stagnant film of fluid. If most of the temperature drop were to occur at the wall, and the bed temperature were therefore nearly unform radially, the methods outlined for homogeneous reactors would apply, and the stable and unstable points could be easily determined.

With a large radial temperature drop in the bed, the stability must be checked by calculating temperature profiles for various assumed center temperatures. If a slight increase in center temperature gives a calculated decrease in wall temperature, the reactor will not be stable. For either approach, the first step is to get data on the rate of heat transfer in the packed bed.

Heat Transfer

Heat transfer in packed beds can occur by five parallel mechanisms:[3]

- Conduction through the gas.
- Conduction through the solid.
- Radiation.
- A series mechanism, from fluid to particle to fluid.
- Turbulent diffusion.

Failure to recognize these five mechanisms, plus the use of different definitions for effective conductivity and Reynolds number, have led to widely different correlations by various workers in this field. The best treatment seems to be that of Smith and his coworkers,[3, 4, 5] though there are more recent data.[6] Typical values of effective conductivity are tabulated below for cylindrical pellets and air at 200-300 C.[6]

Pellet Size, In.	Mass Velocity, Lb./(Hr.) (Sq. Ft.)	Effective Conductivity, k_e, Btu./(Hr.) (Sq. Ft.) (°F./Ft.)
⅛	300	0.16
⅛	600	0.29
¼	300	0.28
¼	600	0.46

The effective conductivity is also a function of radial position because of the nonuniform velocity profile. Up to 0.9 of the distance from center to wall, this effect is not large, so the wall effect can best be treated separately.

The wall coefficient in a packed bed is several times that for an empty tube, as might be expected. Typical values, from Hanratty,[7] are:

	Wall Coefficient, h_w Btu./(Hr.) (Sq. Ft.) (°F.)		
Air Flow, Lb./(Hr.) (Sq. Ft.)	⅛-In. Spheres	½-In. Spheres	⅛-In. Cylinders
300	9	8	20
600	16	14	29

The wall coefficient increases slightly with increasing pipe diameter until a constant void fraction is reached (pipe larger than 10-20 particle diameters).

In the following examples, the problem considered is to determine the radial temperature profiles for

given kinetic and heat transfer data, and to calculate whether a given diameter reactor can be used with a constant wall temperature without danger of runaway temperatures. The axial temperature profiles are similar to those for a homogeneous pipeline reactor (*Chem. Eng.*, May 15, 1961, p. 115). Attention is focused only on the point of maximum temperature, which is assumed to occur near the start of the reactor. Axial conduction is neglected, and the temperature drop from solid to gas is assumed to be small.

A heat balance for an annular element at the point where the axial temperature gradient is zero gives the equation:

$$k_e\left[\frac{d^2T}{dr^2}+\frac{1}{r}\left(\frac{dT}{dr}\right)\right]+aH=0$$

where r = radius
R = radius of reactor
a = lb. moles reacted/(hr.) (cu. ft. catalyst)
H = Btu. liberated/lb. mole reacted
k_e = effective thermal conductivity, Btu./(hr.) (sq. ft.) (°F./ft.)
T = temperature, °F.

To assume a is constant at the value corresponding to the center temperature is the simplest solution, and one that should always be tried first. The equation can then be integrated, or more simply, a new heat balance written for the section inside r.

$$\pi r^2 aH = 2\pi r k_e\left(-\frac{dT}{dr}\right)$$

$$R^2=\frac{4K_e}{aH}(T_c-T_R)$$

The temperature drop at the wall is found from:

$$\pi R^2 aH = 2\pi R h_w (T_R - T_w)$$

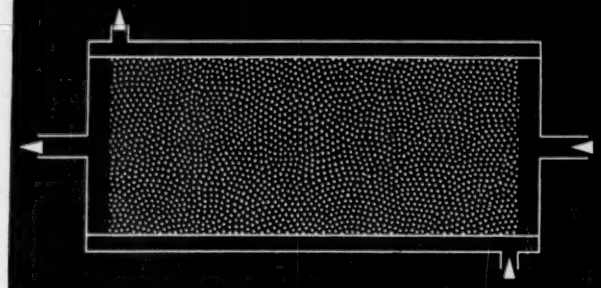
If the temperature drop $(T_c - T_R)$ is small, the assumption of constant a is justified, and there is no reason to seek a more exact solution. Even if the temperature drop corresponds to a twofold or greater change in reaction rate, this simple solution might be enough to show that a proposed design is safe, since it is based on the maximum possible reaction rate.

For a reactor to be stable with a given jacket or wall temperature, a slight rise in reactor temperature must increase the rate of heat removal more than the rate of heat generation. To test this, a slightly higher center temperature is assumed and the required wall temperature for the new steady-state conditions is calculated. If this wall temperature is higher than before, the reactor is stable, since a rise in center temperature at constant wall temperature will lead to more heat transferred than generated. (Resistance of the wall and coolant film in the jacket are assumed negligible for these examples.)

Example 1

Can the following reaction be safely carried out in a 2-in. tube packed with ¼-in. spheres with a maximum temperature of 500 F.?

G = 600 lb./(hr.) (sq. ft.)
k_e = 0.3



More complex than a homogeneous tubular reactor, packed-bed reactor is characterized by . . .

h_w = 16
a = 0.2 at 470 F., 0.4 at 500 F., 0.8 at 530 F.
H = 20,000 Btu./mole
R = 1/12 ft.
T_c = 500 F.

$$(T_c - T_R) \gtrless \frac{(0.4)\ (20{,}000)}{4\ (0.3)}\ \frac{1}{144} \gtrless 46\text{ F.}$$

$$(T_R - T_w) \gtrless \frac{(0.4)\ (20{,}000)}{(12)\ (2)\ (16)} \gtrless 21\text{ F.}$$

$$46 + 21 = 67\text{ F.} \gtrless T_c - T_w$$
$$T_w \gtrless 433\text{ F.}$$

The total heat released would probably be only one-half to two-thirds as great as calculated above, but perhaps stability can be shown even with the larger value.

Assume T_c rises to 510 F. where $a = 0.5$.

$$(T_c - T_R) = 57\text{ F.}$$
$$(T_R - T_w) = 26\text{ F.}$$
$$\text{Total} = 83\text{ F.}$$
$$510 - 83 = 427\text{ F.}$$
$$T_w \lesseqgtr 427\text{ F.,}$$ which is lower than before.

Answer: stability questionable—use more exact solution.

The next step for greater accuracy is to assume the reaction rate to be a linear function of temperature. For ease in manipulation, this is written as:

$$a = C\,(T - T_c) = C\,(y).$$

The constants C and T_c are obtained by fitting a straight line to the important portion of the reaction rate curve (see Fig. 1). The basic equation is then:

$$\frac{d^2y}{dr^2}+\frac{1}{r}\frac{dy}{dr}+\frac{HC}{k_e}y=0$$

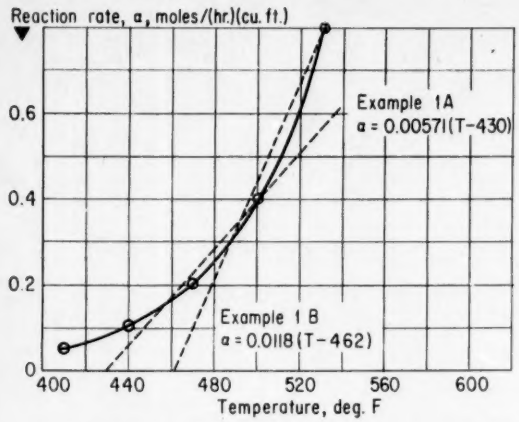
This is a common form of Bessel's equation, and the solution is:

$$y = AJ_c(r\sqrt{K}) + BY_c(r\sqrt{K})$$
where $K = HC/k_e$

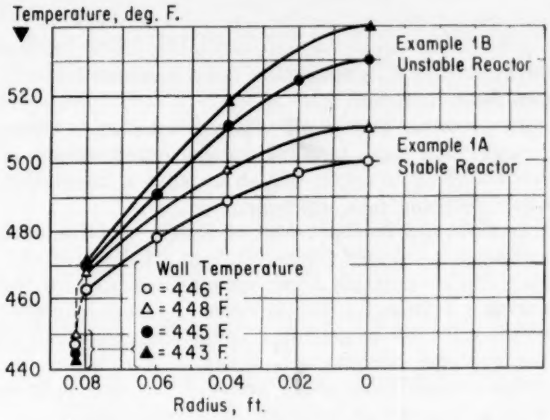
At $r = 0$, $y = (T_c - T_c)$, and the Bessel functions for this limit are $J_c\,(0) = 1.0$, and $Y_c\,(0) = -\infty$. The term with Y_c drops out and the result is:

$$y = (T_c - T_c)\,J_c(r\sqrt{K})$$

The temperature profile is easily obtained using a



... graph of reaction rate vs. temperature (Fig. 1) ...



... and temperature gradient profile (Fig. 2).

table of Bessel functions. The temperature drop at the wall is calculated from the gradient near the wall, which can be found graphically or from the equation:

$$\left(\frac{dy}{dr}\right)_R = \sqrt{K}\ (T_e - T_o)\, J_{-1}(r\sqrt{K}\,)$$

$$= -\sqrt{K}\ (T_e - T_o)\, J_1(r\sqrt{K}\,)$$

$$k_e\left(\frac{dy}{dr}\right)_R = h_w\,(T_R - T_w)$$

Example 1A

Same as example 1, but assume rate is a linear function of temperature

$$\alpha = \frac{0.4}{70}\,(T - 430) = 0.00571\,y$$

$$k = \frac{HC}{k_e} = \frac{(20{,}000)\ (0.00571)}{0.3} = 381$$

$$y = T - 430 = 70\,J_o(r\sqrt{381}\,) = 70\,J_o(19.5\,r)$$

r ft.	19.5 r	J_o (19.5 r)	y	T
0.02	0.39	0.96	67	497
0.04	0.78	0.85	59	489
0.06	1.17	0.69	48	478
0.07	1.37	0.58	41	471
0.08	1.56	0.47	33	463
0.083	1.62	0.44	31	461 = T_R at wall

For wall temperature, get Q from (dT/dr) at wall.

$$J_1(1.62) = 0.572$$

$$\left(\frac{dT}{dr}\right)_R = \left(\frac{dy}{dr}\right)_R = -19.5\ (500 - 430)\ (0.572) = -780\ \text{F./ft.}$$

$$(0.3)\ (780) = (16)\ (T_R - T_w)$$

$$T_R - T_w = 15\ \text{F.}$$

$$T_w = 446\ \text{F. answer}$$

To check stability, assume T_e rises to 510 F.

$$y = 80\,J_o(19.5\,r)$$

$$\text{at } r = 1/12 = R,\quad y = 35,\quad T_R = 465$$

$$T_R - T_w = 15\ (80/70) = 17$$

$$T_w = 448\ \text{F.}$$ Therefore, the system is stable.

Example 1B

Same data as example 1, but desired center temperature is 530 F.

$$\alpha = \frac{0.8}{530 - 462}\,(T - 462) = 0.118\,y$$

$$K = 762$$

$$y = 68\,J_o(r\sqrt{762}) = 68\,J_o(27.6\,r)$$

r	27.6 r	J_o	y	T
0.02	0.55	0.92	62	524
0.04	1.10	0.72	49	511
0.06	1.66	0.42	29	491
0.07	1.93	0.26	18	480
0.08	2.21	0.11	7	469
0.083	2.30	0.06	4	466 = T_R

$$(dT/dr)_R = 1{,}100\ \text{F./ft.}$$

$$T_R - T_w = \frac{(1{,}100)\ (0.3)}{16} = 21$$

$$T_w = 445\ \text{F.}$$

Check stability by letting $T_e = 540$ F.

$$y = 78\,J_o(762\,r)$$

$$\text{at } r = R,\quad y = 0.06\ (78) = 5 \quad \text{or} \quad T_R = 467$$

$$T_R - T_w = 21\ (78/68) = 24$$

$$T_w = 433\ \text{F.}$$

Reactor would be unstable, since a lower wall temperature is required for a higher temperature at the reactor's center.

In example 1A, the more exact calculation shows that the 2-in. reactor would be barely stable with a 500 F. center temperature and 446 F. wall temperature. A 10 deg. rise in center temperature corresponds to a 2 deg. rise in wall temperature. If the center temperature were to rise to 530 F., it would keep on going since a wall temperature lower than 446 F. would be required for steady-state operation. This instability is shown on Fig. 2 by the intersection of the temperature profiles near the wall.

With still-higher center temperatures or a larger tube, the profiles would intersect before they reached the film on the wall.

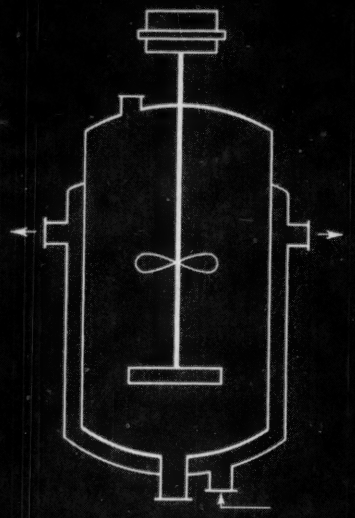
The problem of calculating the center temperature for a given wall temperature is more difficult. If the temperature at the edge of the bed is known, the solution of Wilhelm, Johnson and Acton[3] can be used. But, it is more difficult to decide on an appropriate linear function for α if only the lower temperature limit is known, than if the center temperature were given. When using the method explained here, the Bessel function solution should not be extended past

the limit $T = T_o$, since this would correspond to negative reaction rates.

To continue the profiles in this region, another straight line could be used for the lower section of the reaction rate curve, though a stepwise integration would probably take less time.

In theory, a feedback control system could be used to keep the hot spot temperature at what would normally be an unstable point—as was discussed in the previous article for homogeneous reactors. Because of the difficulty in getting a reliable measurement of the hot spot temperature, a system controlling the jacket temperature would probably be used instead, with a reactor that had some inherent stability.

A different approach to the stability problem was recently presented by Barkelew.[11] By assuming that most of the resistance to heat transfer was at the tube wall, he was able to allow for the effect of feed temperature on reactor stability. However, neglecting the radial temperature gradient in the packing might introduce as much or more error than the assumptions used here. Both methods are probably limited in accuracy by the lack of complete correlations for heat transfer in packed beds.



Simple stirred-tank reactor

Stability of reactors of this type may be determined from curves of heat generated vs. heat removed (Fig. 3). ►

Stirred-Tank Reactors

Stability criteria for stirred-tank reactors are similar to tubular reactors, though equations contain added terms.

The graphs used to check reactor stability for a continuous stirred-tank reactor differ from those for a tubular reactor in two respects. The heat-generated curve does not go through a maximum but becomes asymptotic to a value corresponding to complete conversion of the feed. Also, the equation for heat removed from the stirred tank includes a term for sensible heat in the product. However, since the sensible heat and the heat transferred to coil or jacket are both linear functions of reactor temperature, the heat-removed graph is still a straight line, as in Fig. 3.

The steady-state heat balance is satisfied wherever the heat-generated and heat-removed curves intersect. But, the heat-removed graph must be the steeper of the two for a stable operating point. There might be two stable points and one unstable point for a typical case (as in Fig. 2, for a jacket temperature of 63.5 C.), but the upper stable point is not considered here, since it generally corresponds to so high a conversion that temperature control is not a problem.

The difficult control problems arise when a reactor is operated at low or moderate conversion, either because of byproducts formed at high conversions or because it is the first of several reactors in series. The term, "stable point" must be used with caution, since the detailed analysis of Aris and Amundson[9] has shown that there are two stability criteria for such a reactor. At moderate conversions, a reactor that is only barely stable, according to steady-state analysis, might be unstable to fluctuations of temperature or concentration. Without going into the formal mathematics, the reason for this behavior, and an approximate method for checking transient stability, are presented here.

The graphical criterion for stability previously discussed requires that the reactor be stable *in the steady state* to slight temperature changes. However, the steady-state heat-generated graph allows for the decrease in reaction rate, versus temperature. For momentary changes in temperature, the concentration in the reactor will be almost unchanged, but the rate of reaction may change appreciably, and this change will be more than that shown by the steady-state calculations.

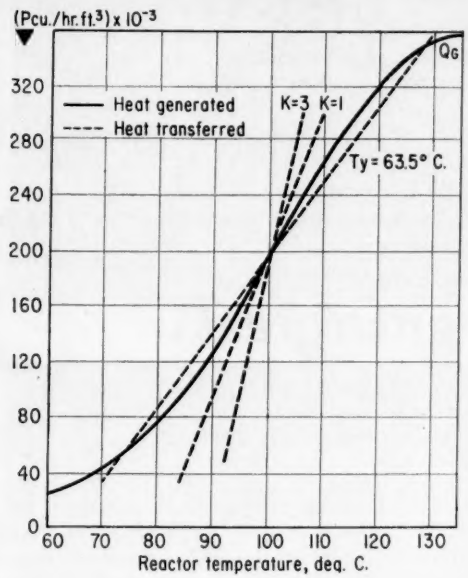
For Example 2, the reaction rate increase 7%/deg. C., and the normal conversion is 50% at 100 C. Fig. 3 shows that a 1 deg. C. rise in temperature would increase the steady-state value of heat generated, from 200,000 to 207,000 pound centigrade units/hr. and increase the conversion to 52%. However, for a sudden rise of 1 deg. C., the conversion would temporarily still be 50%, and the heat generated would increase by 7% to 214,000 Pcu./hr.

For a first-order reaction, it can be shown that

$$\left(\frac{\gamma Q}{\gamma T}\right)_o = \frac{1}{x}\left(\frac{dQ}{dT}\right)_{\text{steady state}}$$

where Q = heat generated
x = fraction conversion

If the slope of the heat-removed graph is greater than $(\gamma Q/\gamma T)_o$, which is twice the slope of the steady-state graph in this case, the reactor will definitely be stable. This gives a slightly conservative answer for the minimum coefficient, because the concentration in the reactor would be slowly dropping following an increase in temperature. For a zero-order reaction, stability in the steady state would be the only criterion



needed. For higher-order reactions, the simplest approach would be to use the fractional increase in reaction rate constant per deg. C. in test for temperature stability.

(This modified requirement for stability was not applied in the case of the tubular reactor because the reaction rate used was the maximum possible rate at each temperature.)

In Example 2, the stirred reactor would be unstable with a jacket temperature of 63.3 C., which is the temperature necessary to remove the heat generated at the desired conditions of 100 C. and 50% conversion. Either the reactor temperature would drop to 75 C., corresponding to 15% conversion, or the temperature would jump to 128 C.

However, the reactor can easily be stabilized with a proportional controller to adjust the jacket temperature as the reactor temperature deviates from 100 C. The slope of the heat-removed line is increased by almost a factor of $(K_c + 1)$ where K_c is the gain of the control system or the decrease in jacket temperature for a unit increase in reactor temperature. The factor of increase would be $(K_c + 1)$ if the sensible heat term were negligible. For this example, the minimum gain is about 1.9 (to give a slope of 14,000). However, a much higher gain would probably be used to get faster control action. Also, even though not needed for stability, cascade control might be used, to minimize temperature deviations resulting from fluctuations in coolant temperature.

Operation of a stirred reactor with a gain only slightly greater than that predicted from the steady-state analysis would probably yield limit cycles of the type found by Aris and Amundson.[9] For Example 2, with a control system gain of 1.0, a sudden slight rise in temperature would increase the rate of heat generation more than the rate of heat transfer. The temperature would rise at an increasing rate until a significant drop in reactor concentration occurred. The temperature would reach a maximum and then decrease, only to go through the cycle again, once the conversion dropped below 50%.

Example 2

F = feed = 1,000 lb./hr. at 70 C, containing 50% A ($C_f = 0.5$)
W = holdup = 1,200 lb. or 1.2 hr.
A = area for heat transfer = 30 sq. ft.
U = over-all coefficient = 150 Pcu./(hr.) (sq. ft) (°C.)
ΔH = heat of reaction = 800 Pcu. per lb. of A.

Kinetics: first-order reaction, $k = 0.1$/hr. at 70 C. Rate doubles every 10 deg. C.

Specific heat of feed and product solution = 1 Pcu./(lb.) (°C.).

Step I: solve for conversion at various temperatures, as shown below.

$$F(C_f - C) = kWC$$
$$C(kW + F) = FC_f$$
$$Q_R = F(C_f - C)(\Delta H)$$

T, Deg. C.	k	C	Fraction Converted	Heat Released, Pcu./Hr.
70	0.1	0.446	0.11	44,000
80	0.2	0.404	0.19	76,000
90	0.4	0.338	0.32	128,000
100	0.8	0.255	0.49	196,000
110	1.6	0.171	0.66	264,000
120	3.2	0.103	0.80	320,000
130	6.4	0.058	0.88	352,000

Maximum heat released = 1,000 (0.5) (800) = 400,000 Pcu./hr.

Heat removed = 1,000 (1.0) $(T - 70)$ + 150 (30) $(T - T_{jacket})$.

Desired operating conditions: 50% conversion, 101 C.

$$200{,}000 = 1{,}000\,(31) + 4{,}500\,(T - T_{jacket})$$
$$T - T_{jacket} = 37.5, \text{ or } T_{jacket} = 63.5 \text{ C.}$$

Slope of heat-removed line = 1,000 + 4,500 = 5,500 Pcu./deg. C.

Use a proportional controller to adjust jacket temperature (or adjust set point of a jacket temperature controller).

For a controller gain of 1.0, $\dfrac{\Delta \text{ jacket temp.}}{\Delta \text{ reactor temp.}} = -1.0$

$T_j = 63.5 - 1.0\,(T - 101) = 164.5 - T$
Heat removed = 1,000 $(T - 70)$ + 4,500 $(T - 164.5 + T)$
= 10,000 T − 812,000

For a controller gain of 3.0,
$T_j = 63.5 - 3.0\,(T - 101) - 366.5 - 3.0\,T$
Heat removed = 1,000 $(T - 70)$ + 4,500 $(T + 3\,T - 366.5)$

Heat-removed graph goes through 200,000 at 101 C. with a slope of 19,000 Pcu./deg. C.

Even though most of the heat of reaction is removed through the jacket, an unstable reactor can be controlled by varying the feed temperature and keeping the jacket temperature constant. This might be preferable if the lag in the cooling system is large. For Example 2, such a control system would have a minimum gain of 8.5, defined as change in feed temperature per unit change in reactor temperature.

A 1-deg. C. increase in reactor temperature would increase the heat transferred through the jacket by 4,500 Pcu./hr. and would cause the feed temperature to be lowered 8.5 C. This would mean 9.5 × 1,000 Pcu./hr. additional heat removed as sensible heat for

a total of 14,000 Pcu./hr. to balance the increase in heat generated.

The high minimum gain of the control system might seem a possible disadvantage at first, since the control loop would also have a maximum over-all gain of 1.0, just as is true for control of jacket temperature. Unless there were a large dead time lag in the control loop, the maximum over-all gain would be much larger than 1.0, perhaps 10-50.

An alternate control scheme is to increase the flow through the jacket or cooling coil rather than change the coolant temperature. This method was used by Aris and Amundson,[9] who got parabolic heat transfer graphs by assuming that the over-all coefficient was proportional to the coolant flow rate. This is an unrealistic assumption since the inside film contributes much of the total resistance to heat transfer for most reactors, but an exact analysis would be difficult.

Dynamic Analysis

The transfer function for the stirred reactor would be similar to that presented for a tubular reactor if the effect of concentration change were neglected.

$$V\rho C\left(\frac{dT}{d\theta}\right) = \left(\frac{dQ}{dT}\right)T - UA\,(T - T_i) - F\rho CT$$

$$\text{or}\quad \frac{V\rho C\left(\frac{dT}{d\theta}\right)}{UA + F\rho C - \frac{dQ}{dT}} + T = \frac{UAT_i}{UA + F\rho C - \frac{dQ}{dT}}$$

where V = reactor volume, cu.ft.
F = flow rate, cu.ft./hr.
Q = total heat generated in reactor, Btu./hr.

The time constant of the stirred-tank reactor would generally be much greater than that of the valve, temperature bulb, jacket, or controller, so that the maximum over-all gain would be quite large. Even with three equal time constants, the maximum over-all gain would be 8.0.

Exact calculation of the maximum gain would involve correcting for the interaction between the lags of the jacket and the kettle, as well as considering the effect of changing concentration in formulating the reactor transfer function. The references[9, 10, 12, 13] present transfer functions for some common cases and discuss the problem of getting more accurate solutions for reactor behavior.

If control of reactor composition is desired, it is better to have separate temperature and composition control loops, particularly if the reactor is barely stable. With a composition controller adjusting the jacket temperature, a sudden rise in reactor temperature is not immediately reflected in a change in composition. If the reactor can be operated isothermally with a suitable control system, the composition control loop can be designed by linearizing the curve of reaction rate versus concentration to get the appropriate transfer function.

For a first-order reaction at constant temperature in a stirred kettle:

input − output = accumulation + reaction

$$FC_f - FC = V\left(\frac{dC}{dt}\right) + VCk$$

$$\left(\frac{V}{F + kV}\right)\frac{dC}{dt} + C = \frac{FC_f}{F + kV}$$

$$C\left[\left(\frac{V}{F + kV}\right)s + 1\right] = \left(\frac{F}{F + kV}\right)C_f, \text{ in transformed notation:}$$

$$C\,(T\,s + 1) = KC_f$$

For the general case where the reaction is not first-order, assume:

$$\text{Rate} = a + bC$$

$$FC_f - FC = V\frac{dC}{dt} + a + bC$$

$$\left(\frac{V}{F + b}\right)\frac{dC}{dt} + C = \frac{FC_f - a}{F + b}$$

If the reaction rate is given by

$$R = k'\,VC^2$$

$$b = \left(\frac{dR}{dC}\right)_{ave} = 2k'\,VC_{ave} = \frac{2R_{ave}}{C_{ave}}$$

As long as the reaction rate increases with concentration, the effective time constant of the reactor for changes in feed concentration is always less than V/F, the holdup time.

Further Work

There is a need for more theoretical and experimental work on reactor dynamics. The control of unstable reactors with dead time in the control loop seems particularly interesting. A pulse disturbance would always grow for an interval somewhat longer than the dead time, and perhaps continuous cycling at low amplitude would result in some cases.

The control of polymerizations must consider the effects of changing concentrations, temperature and viscosity on several simultaneous reactions. For very rapid reactions, diffusion or mixing processes may become important. However, better kinetic data are needed before further work on control systems is justified for some of these cases.

As mentioned by Foss,[13] most reaction systems will probably have a rate-controlling step so that the engineer can use simplified methods similar to those presented here instead of ignoring the control system design because of its apparent complexity.

Meet the Author

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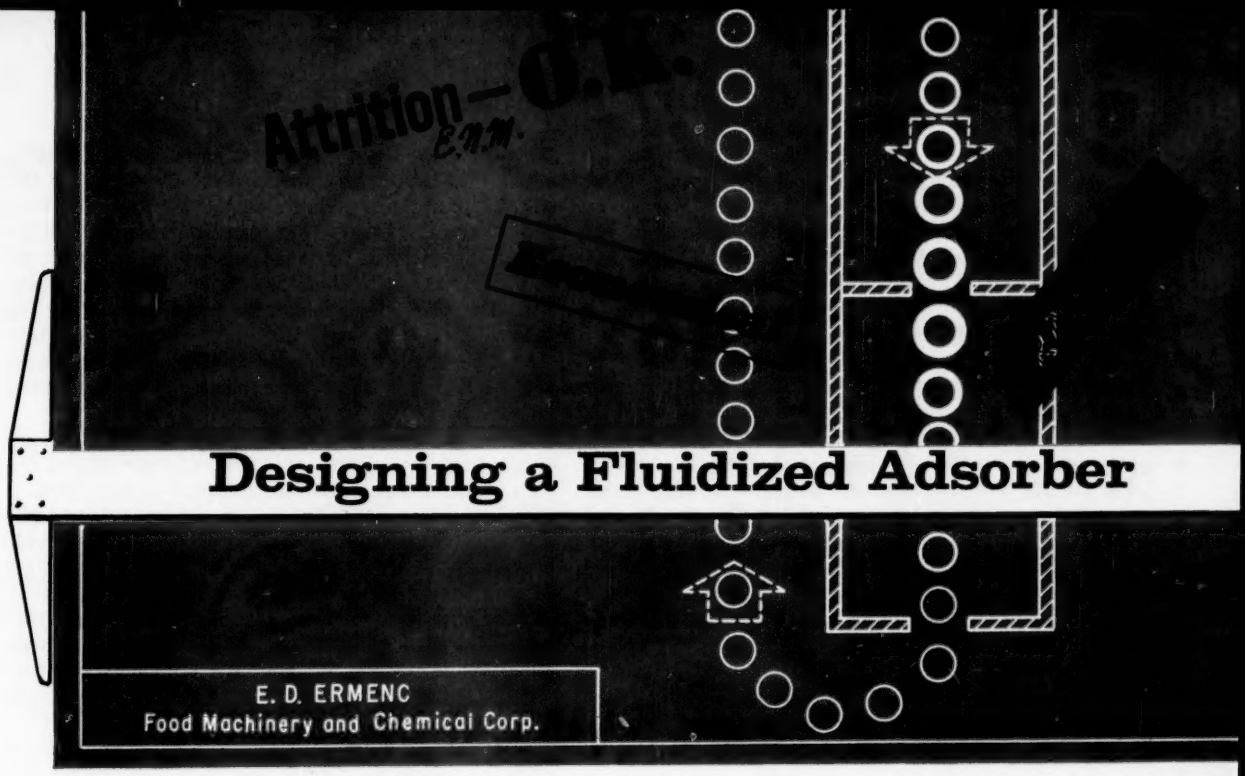
More information on Prof. Harriott will be found at the end of the previous article.

References

A list of the references cited will be found with the previous article, *Chem. Eng.*, May 15, 1961, p. 170.



Designing a Fluidized Adsorber

E. D. ERMENC
Food Machinery and Chemical Corp.

In spite of the well-known adage that continuous systems are better adapted for high capacities, and batch systems for low capacities, few successful continuous adsorption systems have been constructed or described. Excessive attrition losses apparently have been the main deterrent. This need not be so, and data presented here will show that, at least where silica gel is concerned, attrition can be kept low through proper mechanical design.

These data were obtained from operation of commercial-sized units in the demonstration runs of the Wisconsin Process[1, 2]. This process for high-temperature nitrogen fixation was shown to be uneconomic in the U. S. and, as often happens in such cases, the value of individual operational equipment became obscured. The fluidized adsorption system that was part of this equipment was actually workable and economic. Hence I feel convinced that continuous systems should and will receive more and more consideration for utilization in the process industries.

Adsorption in general has certainly been gaining increased favor as a separation technique, as discussed in the extensive report in the Feb. 8, 1960, issue of Chemical Engineering[3]. Once continuous systems receive greater acceptance, the role of adsorption in gas separation should increase further.

In the discussion that follows, we will emphasize the dehumidification of air by silica gel because of the completeness of the available data, and also because this unit operation is of universal interest. The method should be applicable to the dehumidification of other gases or the recovery of valuable components from them. For instance, in our case, we had a second fluidized adsorption tower to recover NO_2 from the dried gas. Silica gel was again used. Application of other adsorbents such as Sovabeads, molecular sieves, alumina, and activated carbon may be possible, particle strength being a major factor.

The use of shallow, fluidized beds for drying of gases is a unique one and has been proved in operation over a period of 12-15 months. The results of this operation from a total process standpoint have been detailed elsewhere.[2] Patents[4, 5, 6] are held by Food Machinery Corp., and equipment information is available from that company. However, these sources give only a general picture of adsorption and more details are necessary.

Low Attrition Vital

Favorable adsorption economics depend on low attrition rates. Our water adsorption tower was very good in this respect, and the results of tests made in both the laboratory and in actual operation will be presented. While the attrition losses measured in the laboratory were considerably less than those experienced in the plant, the plant losses were still quite low.

We performed many attrition loss experiments in the laboratory, and the results of one are illustrated. In this test, Davison Chemical Co.'s 10-14-mesh Grade 05 gel was circulated through a 2½-in.-dia. lift tube at a rate of 2 lb./min. Gas velocity was 22 ft./sec. The gel charge of 25 lb. was periodically removed, weighed and returned to the equipment. A cyclone in the air system removed and weighed the dust.

The results of a 40-day attrition test are shown in Fig. 1. The large initial loss is caused by rounding

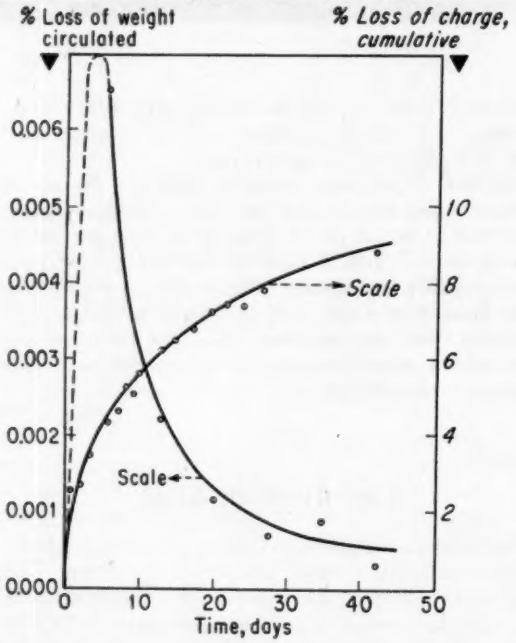
of the corners of the gel plus losses due to fracturing of gel particles along stress planes. Rounding of gel makes it less susceptible to attrition since sharp corners tend to flake and break. The rubbing of gel particles, one against the other, provides the desired rounding effect. This initial loss thus approaches 10% of the original charge and the loss rate approaches a constant value of 0.0005% of the gel circulated.

Other tests were made in a pilot adsorber tower in which gel passed through 28 fluidized trays, 10 finned-tube exchangers, a gel valve, reservoir, and air lift. Gel temperature ranged from 50 F. to 350 F. The attrition rate became very similar to that noted above on the air lift test. We observed that low attrition rates resulted from limiting the free fall of gel on metal surfaces, indicating that under conditions of smooth dense-phase fluidization, attrition need not be a severe problem.

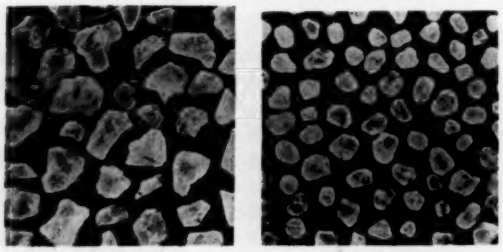
Fig. 2 shows photographs of fresh charged gel and the results of long-time circulation. You can readily notice the sharp irregular shape of virgin gel and the occasional fracture planes along which some particles will eventually break. The second photograph illustrates the ultimate rounded shapes of gel particles and hence points up their resistance to further breakage. The photos also illustrate the reduction in size that occurs, although the relative size reduction shown here was probably not typical. These pictures are not from the same experiment, but were selected merely to show how gel can be rounded.

To be sure that no changes would occur on scale-up of air lifts, we constructed a full-size air lift in the pilot plant, utilizing a 10-in.-dia. pipe capable of handling a gel flow rate of 600 lb./min. The air lift was run as a closed system similar to the smaller unit previously described. Attrition of the circulated gel ranged from 0.015% initially, to a final 0.0014% as adjustments were made to reduce losses. Pre-attrited gel was used in these tests, and gel flow rates varied from 250 lb. to 600 lb./min. We thus obtained reasonable assurance that gel losses could be kept within bounds in the plant.

Gel attrition rates – Fig. 1



Rounding of silica gel—Fig. 2



New gel Used gel

However, on startup of the water adsorber tower (Fig. 3), losses were extremely high, and it took the combined efforts of all personnel to lick the following problems that developed:

• **Static Charge.** Due to the degree of dryness desired, static-charge buildup caused large losses of gel. It was only on observing the functioning of the plates that we saw that the gel was acting strangely —clumping together and clinging to the sides of the column after a period of excessive loss. Once we had this visible proof of static-charge buildup, the solution was simple. We added small amounts of carbon and had no more trouble. Addition of carbon became a regular operating procedure.

• **Air Lift Disengager.** This unit separated the gel from the air stream at the top of the tower. We observed that gel was impacting heavily against the screen in the gas discharge. This was obviously contributing to breakage. We lengthened the disengager, and losses from this source were thereby eliminated (Fig. 3).

• **Gas Distribution at Drying Tower Exit.** One 20-in.-dia. duct removed the dried gas, and we thought it probable that poor gas distribution occurred at the tower discharge point. Installation of a header with slot opening extending across the tower diameter provided much improved velocity patterns and reduced losses.

• **Losses from Regenerator Section.** High losses also occurred here, but this was due to excessive gas velocities. We corrected this by reducing gas flow to 50-60% of design.

• **Elimination of Gel to Metal Contact.** In all cases, direct drops of gel to metal were eliminated. We allowed gel to drop only on beds of gel. The drops were made as small as mechanically feasible.

With all of the above steps accomplished, gel losses were reduced to 1-3 lb./hr., gel flow rates being 100-150 lb./min. or 6,000-9,000 lb./hr. Losses were thus

between 0.01% and 0.03% of the gel flow rate, or at a rate that we could live with. No more work was done on attrition at this point, although the laboratory tests indicated that even lower rates could be attained—perhaps as low as one tenth of those actually experienced. Even at the higher loss rate of 3 lb./hr., dust loading in the gas being processed was less than 1 grain/cu. ft.

Had it been necessary to reduce attrition still more, the following steps could have been considered:

1. **Use of Pre-attrited Gel.** The initial loss of up to 10% of the charge could be eliminated through use of pre-attrited gel if commercially available. An alternative would be to circulate the rough gel for a period of 48-72 hr. before placing the unit on stream to provide for pre-attrition.

2. **Use of Spherical Drying Media.** Spherical particles or beads of silica gel would reduce the attrition problem substantially if available at reasonable cost. Other drying agents could be considered if they promised impact strength and adsorptive capability at least equivalent to that of silica gel.

3. **Reduction of Tower Velocities.** Attrition loss is a function of the gas velocity in a particular system. However, lowered velocities would have to be justified on the basis of larger equipment cost vs. reduction in gel losses.

Gas velocity in our drying tower was 4.5 ft./sec. At this velocity, only particles finer than 35 mesh could be carried out by the gas.

4. **Mechanical Design.** Close attention to all phases of gel handling might reveal further improvements. All gel to metal contact on free fall should be eliminated, and excessive momentum buildup prevented. In other words, gentle slides, with beds of gel to cushion the fall of incoming gel, are recommended.

Attrition, then, should not be a deterrent to the use of continuous fluidized columns of silica gel for drying of air or other gases. In fact, it is surprising that not more has been accomplished in this field. Batch processing large quantities of gases is somewhat archaic, necessitating multiple installations that are costly in equipment and area requirements. As for continuous operation, assuming a 12-ft.-dia. unit is the largest shop-fabricated unit that can be manufactured and transported, approximately 30,000 cu. ft./min. capacity units at atmospheric pressure are feasible. Higher pressures would, of course, increase the capacity of a unit.

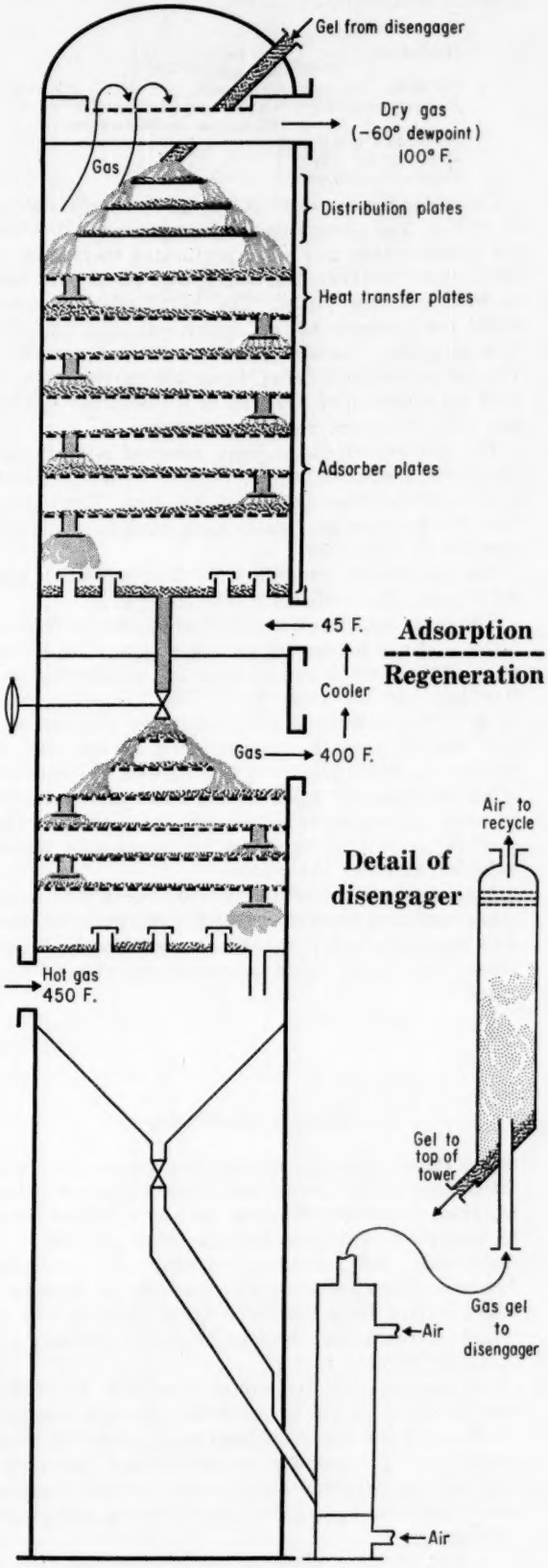
Anatomy of Adsorber

The water tower for removal of water from a wet gas was constructed as shown in Fig. 3. Design data were as follows:

Pressure—	essential atmospheric
Gas capacity—	22,000 std. cu. ft./min.
Gas entering:	Dry bulb—45 F.
	Wet bulb—45 F.

(*Continued on p.* 90)

H_2O adsorption tower – Fig. 3



FLUIDIZED ADSORBER . . .

Gas leaving:	Dry bulb — 100 F. Wet bulb— −60 F.
Gel flow	80 lb./min.
Pressure drop	0.6 psi. adsorption section 0.4 psi. regenerator section
Adsorption trays	6
Heat transfer trays	2
Regenerator plates	5

The water tower was 10 ft. in dia. by approximately 70 ft. tall. The adsorption section contained a bubble-cap entrance tray and seven perforated trays, five of which were designated as adsorption plates and two as heat transfer plates. The heat transfer plates cooled the incoming hot gel, which was at a temperature of 250 F. The new gel was 6-12-mesh material. The gel loading of 6 lb./sq. ft. or 450 lb./plate gave a total gel retention of 3,600 lb. in the adsorber section and 2,300 lb. in the regenerator section.

The perforated plates were punched with ⅛-in.-dia. holes, spaced to provide an open area equivalent to 13% of the tower cross sectional area. There were four downcomers per plate, each having roughly a capacity of 50 lb./min.

The gas velocity based on the full cross section was 4.5 ft./sec. Plate efficiency was 80-90%.

The regenerator section consisted of four perforated plates and one bubble cap entrance plate. The plates were of the same design as those in the adsorber section and had the same gel loading. However, only 50-60% the quantity of gas used in the adsorber section was required. In our operating system, part of the hot gas to be dried was first used as the regenerating medium, and a condensing cooler was provided between the regenerator and adsorber sections. The rest of the hot gas bypassed the regenerator plates, going directly into the cooler.

In a system mainly for drying cool air or some other cool gas, the regeneration fluid could be handled separately and recycled to conserve heat. A portion of the recycle would be purged and make-up provided.

Design Methods

The design of continuous fluidized columns is facilitated through the use of the Lewis method of determination of number of plates, the Lewis method being to adsorption what the McCabe-Thiele method is to distillation. All you need are data—and isotherms for water-silica gel are readily available. A convenient chart derived from the isotherms is found in Fig. 4., which combines data obtained by Food Machinery and Davison Chemical Co.[7]

As you can note, the values below 0.01 lb. of H_2O per lb. silica gel are extrapolated, which is adequate for design purposes. An expansion of these data would be desirable for regeneration calculations, but the design of our unit was based purely on heat transfer considerations. It included safety factors, and proved adequate.

A plot of plate efficiency—which is a function of

Vapor pressure of water over silica gel – Fig. 4

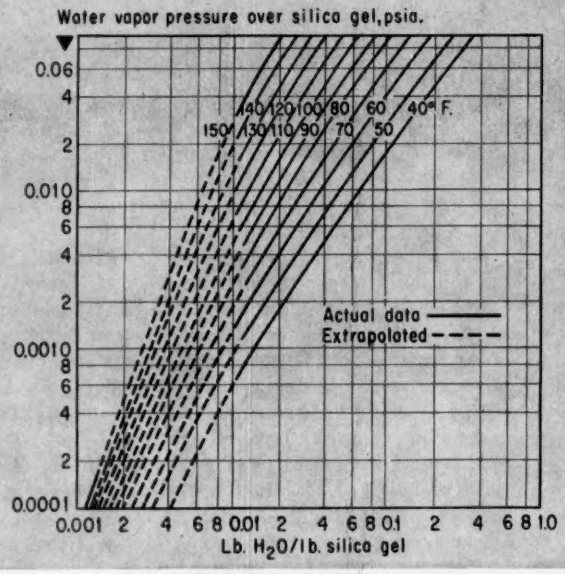
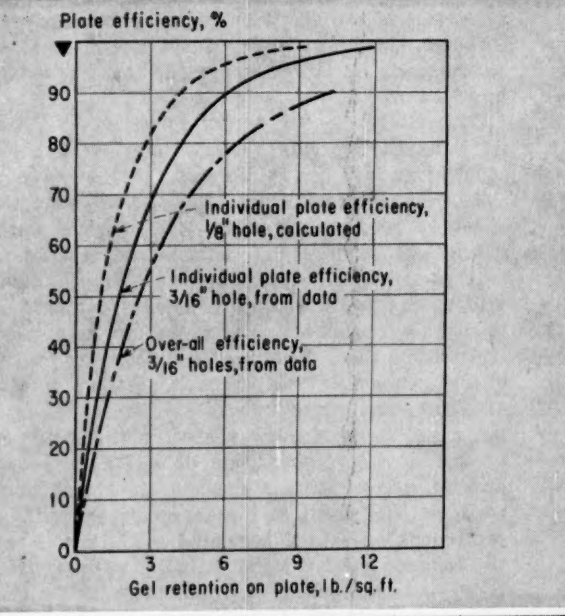
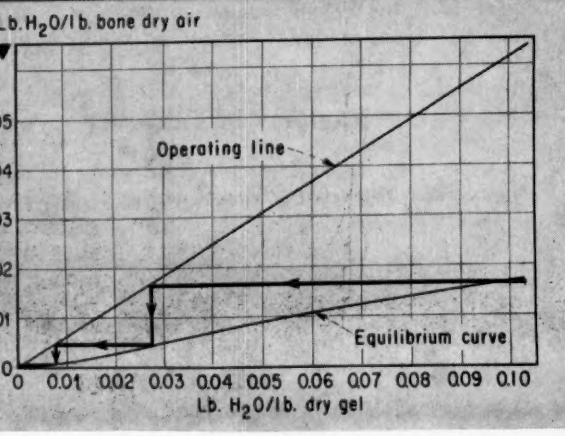


Plate efficiencies for drying column – Fig. 5



Stepping-off theoretical plates – Fig. 6



the depth of gel on the plate—vs. unit gel retention is shown in Fig. 5. The over-all plate efficiency is lower than that of the individual plates since adiabatic conditions are involved. Under isothermal conditions, the over-all and individual plate efficiency is the same. In actual practice, individual plate efficiency varies from plate to plate, the values shown being average. Plate efficiencies for adsorption of water are quite high due to high mass transfer coefficients. Other components will vary in these values, NO_2 adsorption for instance giving plate efficiencies of approximately 30% for the same unit gel loading and plate hole-size.

While isothermal operation can be considered, the internal heat exchange that would then be needed would raise costs and introduce potential plugging problems. Although the pilot plant used internal heat exchange successfully, adiabatic operation provided for a less complicated, less costly installation and proved to be highly satisfactory.

In an early edition of "Chemical Engineers' Handbook,"[8] individual plate efficiency for distillation was defined by the relation:

$$E = 1 - e^{-KL/D}$$

where E = plate efficiency
e = Napierian logarithm base
K = constant
L = effective depth beneath liquid surface
D = effective bubble diameter

This relationship does not show up in later editions and hence can be assumed to be less applicable to distillation than once thought. It is interesting that if we apply the equation to solid-gas adsorption for a plate hole-size of ¼-in., an improvement in efficiency is indicated in Fig. 5.

Above the 6-lb.-gel./sq. ft. retention level, the increase is not too great, but where low efficiencies are met, smaller plate hole-sizes with greater surface for mass transfer may effect considerable improvement. However, substantiation would be required.

Fig. 5 also shows that efficiencies start leveling off at the 6-lb.-gel/sq. ft. retention, and hence this figure was used in design of the column.

Knowing the equilibrium relationship between water and silica gel, an equilibrium curve can be constructed as discussed below. Having set the inlet and outlet conditions of the gas, an operating line can be drawn. The two curves are shown in Fig. 6. In accordance with the usual procedure, the theoretical plates are then stepped off, the over-all efficiency is obtained from Fig. 5, and the actual plates calculated.

To arrive at the equilibrium curve, a heat balance is made over the whole column and temperature conditions are established. We may assume that the entrance gel and exit gas approach within 10 F. of each other. The heat transfer coefficient between gel and gas has been determined to be approximately 0.3 Btu./min. × °F. × lb. gel in the adsorber section. By trial and error, the exit gel temperature can then be calculated.

To better illustrate, a problem is worked out below, in which approximately 21,000 std. cu. ft./min. of air at 45 F., saturated, is to be dried to a dewpoint of −60 F. at a gel flow of 90 lb./min.:

Terminal Conditions

Exit gas—0.00002 lb. H_2O/lb. dry air
Entering gas—0.0061 lb. H_2O/lb. dry air
Leaving gel—0.10 lb. H_2O/lb. dry gel

Gas Analysis

	lb.-moles	lb./min.
O_2	11.9	390
N_2	42.6	1,200
H_2O	0.5	9
	55.0	1,599

Approximate Enthalpy Balance

Gas In

Sensible heat gas	$1,590 \times (0.24)45 =$	17,200
Sensible heat vapor	$9 \times (0.47)45 =$	200
Latent heat vapor	$9 \times 1,000 =$	9,000
Heat of wetting	$9 \times 100 =$	900
		27,300

Gel In

Sensible heat gel $\quad 90 \times 0.2T_1 = 18T_1$

$27,300 + 18T_1$

Gas Out

Sensible heat gas $\quad 1,590 \times 0.24 \times T_3 = 382T_3$

Gel Out

Sensible heat gel $\quad 90 \times 0.2 \times T_2 = 18T_2$
Sensible heat water $\quad 9 \times 1 \times T_2 = 9T_2$

Total heat out $\quad 382T_3 + 27T_2$

$$Q \text{ in} = Q \text{ out}$$
$$27,300 + 18T_1 = 382T_3 + 27T_2$$
Assume $T_1 - 10 = T_3$
$$31,100 = 364T_1 + 27T_2$$
Assume $T_2 = 60$ F.
$T_1 = 81$ F.
and $T_3 = 71$ F.

In calculating the Log Mean Temperature Difference
$\Delta t_1 = 60 - 45 = 15$
and $\Delta t_2 = 81 - 71 = 10$
This gives a LMTD of 12.3

In deriving the LMTD from the Heat Duty, let us assume there are six actual plates, which at 6 lb./sq. ft. gives us 2,700 lb. gel loading. The heat duty can be calculated by the usual methods and amounts to 10,200 Btu./min.

$$\text{Hence:} \quad \text{LMTD} = \frac{10,200}{2,700 \times 0.3} = 12.6$$

This checks closely enough with the LMTD of 12.3 obtained earlier.

The equilibrium curve can now be calculated below. Arbitrary increments in Col. I are set down and a temperature distribution made on the basis of these increments in Col. II.

Col. III is read from Fig. 4 and Col. IV is calculated from Col. III via

$$\frac{p}{P - p} \times \frac{18}{29} = \text{lb. } H_2O\text{/lb. dry gas.}$$

I lb. H_2O/lb. gel	II Temp.,F.	III p over gel-psi.	IV lb. H_2O/lb. dry gas
0	81	—	—
0.005	80	0.00068	0.000028
0.01	79	0.00245	0.000101
0.03	75	0.0130	0.000540
0.05	70	0.0225	0.000933
0.07	66	0.030	0.00124
0.10	60	0.040	0.00166

Fig. 6 is constructed and from it we see that we need approximately three theoretical plates. At 80% over-all efficiency, four actual plates are indicated. Allowing for reduction in efficiency of gel with time, plus some safety factor, increases the actual plates

to six. The assumption of six plates in the problem is thus verified.

The heat transfer plates can readily be calculated as follows:

Heat from gel $90(0.2)(300 - 71) = 4100$ Btu./min.
Heat to gas $382\,\Delta t = 4100$
$\Delta t = 11$ F. or gas out is 82 F.
LMTD = 68

Assume two plates: $\dfrac{4{,}100}{0.06 \times 900} = 76 = \text{LMTD}$

Hence, two plates would be close; use three to be safe.

Regeneration requirements are similarly calculated based upon heat transfer requirements, except that only about 60% as much gas is required as is dried in the adsorber.

Gel Heat Duty $Q = 90(0.2)(300 - 60) + 9(1{,}000) + 9(100)$
$= 14{,}200$ Btu./min.
From heat balance: gas temp in = 350 F.
gas temp out = 300 F.
LMTD = 115
check LMTD and assume five plates

$$\text{LMTD:}\quad \frac{14{,}200}{0.06 \times 2{,}250} = 105$$

5 plates are adequate

Summary:

Adsorber plates	6
Adsorber heat transfer plates	3
Regenerator plates	5

Note that the heat transfer coefficient under condensing conditions in the adsorber is 0.3, and under straight heat transfer and removal of moisture is 0.06.

Operating Features

Downcomer design (see Fig. 7) might be of interest. The unit was quite simple. The flat check-plate placed at the gel discharge was held in place by a spring; gel weight compressed the spring allowing gel to pass. In case the downcomer ran empty for any reason, the check plate closed, preventing the gas from bypassing the gel. Four 3-in. pipes were installed per plate to handle the flow of gel, enabling gel flows of up to 200 lb./min. The pipes were placed so as to allow cross-plate mixing before discharging to the plate below.

Instrumentation was relatively simple. Pressure drop across the regenerator and adsorber was measured, and the pressure drop across the first adsorber plate—the bubble cap plate—was used to automatically control the flow of gel from the adsorber to the regenerator section. We measured the flow of gel from the regenerator hopper to the gel lift by observing the time a particle of gel took to traverse a given distance—a glass sight port having been provided in the discharge duct. Air flow was varied at the gel lift to provide for lesser or greater flows.

Since this method of measuring gel flow was unsatisfactory as an absolute measure, we made occasional gel and gas analyses to accurately determine the flow. A refinement would be to provide a solids measuring device.

The gas temperature at every other plate was measured by indicating thermocouples. The temperature of the inlet and exit gas was recorded. Every other plate had a sample port for dewpoint measurement and to enable removal of gel for analyses or temperature measurement.

The most satisfactory dewpoint measurements were made manually by the dewpoint cup method. We encountered some difficulties due to the presence of NO_2, but in other systems this would be no problem.

Qualitative observations of fluidization were made before actual operation of the column to determine the optimum operating point. We varied the bed-depth of gel and the gas flow to arrive at the fluidization zones shown in Fig. 8. Gas temperature ranged between 200-300 F. in these tests, but temperature did not appear to have any appreciable effect on fluidization appearance. Actual jet velocity appeared to be

Actual operating data—Table I

Hours after start-up	2	4	16
Gas flow, std. cu. ft./min	22,000	22,000	21,500
Measured gel rate, lb./min.[1]	38	38	37
Exit dew point, °F	−70	−60	−70
Regenerator entry, °F	304	330	345
Regenerator plate 2, °F	284	304	316
Regenerator plate 5, °F	261	285	298
% Free water	0.7	0.8	0.3

[1] Measured gel rates were always lower than gel rates calculated from a water balance. At the time these data were taken only the measured gel rates were recorded. Actual gel rate (calculated) was probably in the range of 80–120 lb. min.

Regenerative data on startup—Table II

	Dew-point °F.	Gas Temp. °F.	Gel Temp. °F.	H_2O Content lb./min.
Regenerator gas[1]		451		35.4
Regenerator plate 2		419		
Regenerator plate 5		395		
Adsorber gas, entering[2]		43		7.0
Adsorber Plates				
No. 1	20		66	
No. 2	0	77	74	
No. 3	−15			
No. 4		89	77	
No. 5	−55			
No. 6		91	82	
No. 7	−45			
No. 8	−62	99		nil
Adsorber gel entry[3]		250		0.2
Adsorber gel exit				7.2

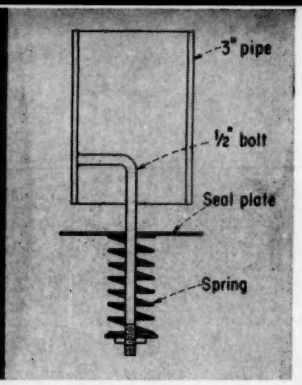
Gel flow—82 lb./min. (calculated from water content)
[1] Gas flow—17,800 std. cu. ft./min. [2] Saturated gas. [3] Free water—above the normal held water of approx 5%.

Plate data, various conditions—Table III

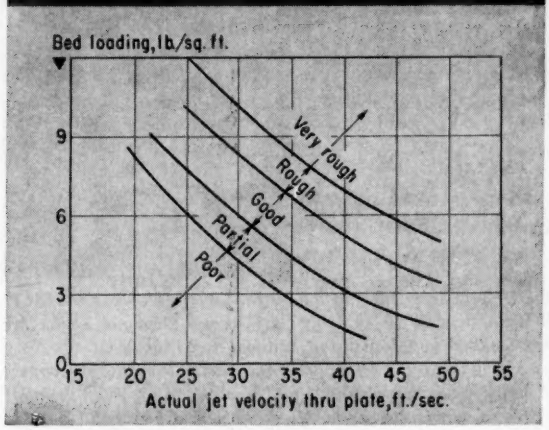
	Actual	A	B	C	D
Entering temp., F	45	60	60	60	60
Entering dewpoint, F	45	60	60	60	60
Exit dewpoint, F	−60	−60	−20	−60	−20
Adsorption plates, No	5	8	5	6	4
Heat transfer plates, No	3	4	4	7	7
Desorption plates, No	5	6	6	7	7
Gel flow rate, lb./min	90	180	180	300	300
Gas flow, std. cu. ft./min		<———	32,000	———	>
Column velocity, ft./sec		<———	4.5	———	>

Downcomer permits gentle gel flow, limits gas flow

Fig. 7



Fluidization zone observations – Fig. 8



the main criterion in providing good fluidization. The latter is characterized by a uniformly bubbling mass of gel; with rough fluidization there are high spurts of gel in the boiling mass.

Table I shows actual data obtained on the operating adsorption column at a gas flow of 18,000 std. cu. ft./min., resulting in a −60 F. dewpoint gas. Gel temperatures shown are obviously too low, as these should be higher than the gas temperatures. The method of measurement was thus not satisfactory. The gas temperatures and dewpoints were reliable.

Table II gives some actual data on the regenerator section during a startup, showing the rapidity with which a column can be brought on stream.

Table III shows the results of plate requirement calculations based on data obtained from actual operation. Col. I summarizes the results of calculations made earlier in the article—these parallel the operation of the actual installation. Cols. II A and B illustrate the variations in requirements upon alteration of the dewpoint condition. Obviously, as the dewpoint requirement is raised, the required adsorption plates decrease. Cols. II C and D show the effect of increased gel flow rate. Entering gas temperatures higher than 60 F. could be utilized, although this would mean increased gel flow rates and higher attrition losses. Cooling the entry gas requires lower gel flow rates; the cost of additional capital equipment can be weighed against attrition savings.

Where dust may have an effect on subsequent operating steps, it would be advisable to cool the gas, to reduce dust loss to a minimum. A filter would be required after the column if dust concentrations of even a few grains per cubic foot were undesirable. Normally, the dust loading obtained without these measures should be of little concern. Dust loadings have been noted in actual operation to be less than 1 grain/cu. ft. at 100-150 lb./min. gel rate and approximately 3-4 grains/cu. ft. at 500-600 lb./min. gel rate. As noted earlier, laboratory attrition rates have been considerably lower than these values, indicating that further reduction in gel loss and dust loadings is possible under commercial operating conditions.

Silica gel loses activity as adsorption and regeneration cycles continue, hence we were not surprised when, after months of operation, gel activity had lowered to 83% of original value. This factor can readily be taken into account during design.

Batch vs. Continuous System Economics

Equivalent designs of batch and continuous systems were made to attempt to arrive at a fair comparison of capital and operating costs. A design loading of 500 lb. H_2O/hr. was assumed, and the cheapest batch system, a two-unit assembly, was designed. Fig. 9 shows comparative sketches of the two systems.

We designed the batch vessels on the basis of a velocity of 50 ft./min. in the free cross section, and provided sufficient gel for 24-hour operation per unit, or a 48-hour cycle. The gel requirement was based on a 60% utilization of the total fixed bed before breakthrough.

As shown in Fig. 9, the main difference in capital expense is due to the high cost of the initial charge of gel in the fixed bed system. This charge is not included in the usual adsorption system cost. But it should be, as it is an integral part of the cost. Hence, the batch system costs approximately 1½ times more

Comparative operating costs—Table IV

	Fluidized Bed $/Yr.	Fixed Bed $/Yr.
Operating labor	¼ man 1,500	½ man 3,000
Maintenance labor & materials	3% capital 3,000	2% capital 2,900
Payroll Added Costs at 15%	500	700
	5,000	6,600
Utilities		
Gas 8,000,000 cu. ft. @ 50¢/M.	4,000	15% more 4,600
Power 150,000 kwh. @ 1¢/kwh.	1,500	15% more 1,700
Silica gel make-up 16,000 lb./yr.	5,300	5,300
	10,800	11,600
Taxes & insurance, 3% capital	3,000	4,400
Depreciation, 10% capital	10,000	14,500
	13,000	18,900
Overhead	1,500	1,500
Total operating cost	30,300	38,600

Based on 8,000 hr./yr.

than the continuous system under the stated conditions. Cooling system requirements have not been shown in either case.

Capital charges were scaled upward on the basis of the Marshall and Stevens index at 237. Use of the *Engineering News-Record* index at 800 would indicate 10% higher costs than shown.

Table IV compares the annual operating cost of each system. An advantage was given the continuous system on labor, and the batch system on maintenance. Gas and power were indicated to be somewhat less for the continuous system. We based silica gel makeup on average losses in actual operation of the fluidized bed system, and made a similar charge for the fixed bed system, thus providing for a gel life of 12 years in the latter. Taxes, insurance and depreciation were based on capital. Overhead charges were assumed to be the same in either case. Operating charges are thus 25% lower for the continuous system.

In conclusion, we hope we have shown that the continuous fluidized system can fulfill a need in the process industries for large-scale drying of gases, and gas separations. We believe that batch operation will still have a place but will be relegated to its proper position in the usual continuous-vs.-batch considerations—continuous for large capacities, batch for small ones.

ACKNOWLEDGMENT

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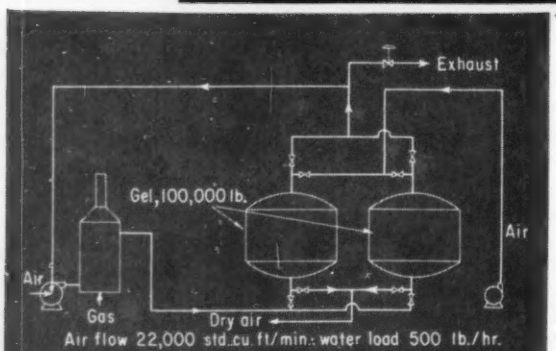
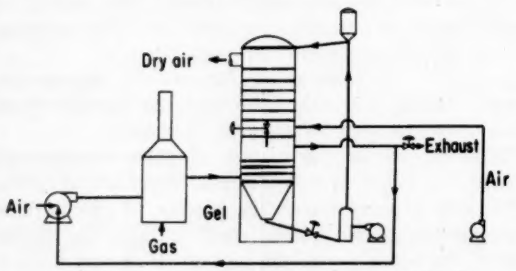
Continuous vs. equivalent batch system – Fig. 9



Air flow 22,000 std.cu.ft/min.; water load 500 lb./hr.

Fixed bed

	Equip. & Matl.	Labor	Total
Two vessels, 22 ft. dia.	26,000	10,000	36,000
Platforms	2,000	1,500	3,500
Silica gel charge—200,000 lb. @ 33¢/lb.	66,000	2,000	68,000
Indirect Heater	14,500	4,500	19,000
Instrumentation	500	300	800
Foundations	400	2,000	2,400
Wiring	500	1,500	2,000
Piping	9,000	5,000	14,000
			145,700



Air flow 22,000 std.cu.ft/min.; water load 500 lb./hr.

Fluidized bed

	Equip. & Matl.	Labor	Total
Adsorption tower	53,000	5,300	58,300
Gel lift blower	3,300	500	3,800
Platforms	4,000	3,000	7,000
Silica gel charge—10,000 lb. @ 33¢/lb.	3,300	1,200	3,500
Indirect heater	9,500	4,000	13,500
Instrumentation & control valves	3,000	1,500	4,500
Foundations	500	2,500	3,000
Wiring	500	1,500	2,000
Piping	2,500	2,500	5,000
			100,600

Simultaneous Transfer of Heat and Mass

How to analyze and calculate heat and mass transfer, simultaneously when resistance occurs in the laminar boundry layers between two fluid phases in contact at the interface.

JESSE COATES and BERNARD S. PRESSBURG
Louisiana State University

Humidification, water cooling, drying and a number of other operations involve the simultaneous transfer of heat and matter between phases. Interest may be in one transfer or the other, such as in the energy changes in water cooling, or in the mass transfer in dehumidification. However, in all these operations, each transfer influences the other and must be taken into account in designing or analyzing the equipment in which the operation takes place.

In previous refresher articles,[1] we have shown how to treat heat transfer or mass transfer when either takes place alone. In this article, we will show the specific considerations and techniques that enter when both mass and heat transfer take place at the same time.

We will discuss this as a rate problem in which the resistance to transfer exists primarily in the laminar boundary layers that are present when two fluid phases are in contact. This limits us to gas-filled systems, such as the humidification processes, and to convection as our transfer medium. In a forthcoming article, we'll examine a solid-fluid system such as drying in which conduction, or conduction and radiation may also be significant.

Let's see how basic fundamentals apply to this situation by looking at a typical section—for example, somewhere in a dehumidifier. Conditions of temperature and concentration under which the mass (water) is being transferred are shown in Fig. 1.

First, material and energy balances can be written to account for the interphase transfer in the differential section shown in Fig. 1:

$$dN = d(Gy) = -d(Lx)$$

$$d(q_{sens.})_L = \lambda_m\, dN + d(q_{sens.})_g \quad (1)$$

or:

$$LdT = \lambda_m\, dN + GC_m\, dt \quad (2)$$

In this application, $y = p/P$ and $x = 1.0$ since water is the only component of the liquid phase. Eq. (2) may be recognized as a specific statement of the enthalpy balance: $d(i_g) + d(i_L) = d(q)$. Eq. (2) applies to the adiabatic case in which q, heat exchange crossing the boundaries of the system, is zero as opposed to heat exchange from one phase to the other within the system.

The rates of heat transfer and the rate of mass transfer within this section are given by Eqs. (3) and (4), respectively:

$$d(q_{sens.})_L = h_L\, dA\, (t_i - T) \quad (3)$$

$$d(q_{sens.})_g = h_g\, dA\, (t - t_i) \quad (3a)$$

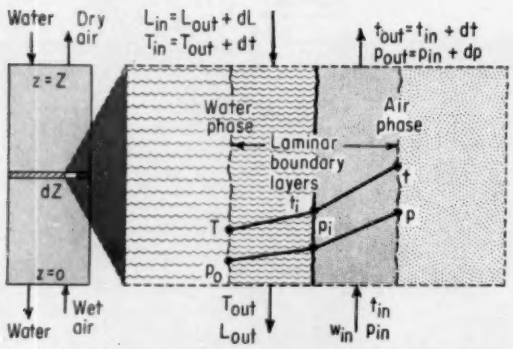
$$dN = k_c\, dA\, (c - c_i) \quad (4)$$

In these equations, it is more convenient to use individual film-coefficients than the over-all coefficients discussed in absorber design.[1] As shown in Eq. (2), the rate of heat transfer is not the same across the liquid- and gas-phase boundary layers, and the definition of an over-all coefficient is not as simple as cited in the previous operations.

For systems such as these where the phase boundary may be irregular or difficult to determine, we can express the contact area in terms of the volume under consideration:

$$dA = a\, d(Vol.) = aSdz \quad (5)$$

In many applications, it is more convenient to use



Mass and heat transfer relations in dehumidifier section—Fig. 1

partial pressures or fugacities instead of moles per unit volume to express concentration. Eqs. (3) and (4) can be rewritten as:

$$d\,(q_{sens.})_g = h_g\,a\,S\,dz\,(t - t_i) \tag{6}$$

$$dN = k_g\,a\,S\,dz\,(p - p_i) \tag{7}$$

If the usual assumption that the interfacial resistance itself is negligible is accepted, phases are in equilibrium at their point of contact. Thus, Eqs. (6) and (7) are not independent but must satisfy the requirement that p_i is the equilibrium vapor pressure p^* of the water at the temperature t_i.

The concept that the phase resistance to transfer is determined by the velocity distribution and the effective thickness of the laminar boundary layer adjacent to the interface requires that the heat and mass transfer coefficients be proportional.

The heat transfer coefficient may be visualized as k_t/X and the mass transfer coefficient as D/X. Thermal conductivity k_t and mass diffusitivity D are both physical properties. Since these properties and the effective thickness of the laminar layer X are substantially the same for both heat and mass transfer, any change in flow conditions must affect both coefficients in the same manner and to the same extent.

These basic equations can be applied satisfactorily to such diverse unit operations as the humidification processes, nonisothermal absorption and stripping; and vaporization, condensation or nonadiabatic distillation in which it is desired to determine quantitatively the resultant degree of fractionation.

Eqs. (1) through (7) are, as stated, point values. To be of use, they must be integrated between preestablished terminal conditions, or for an apparatus of specified dimensions. The techniques for integration differ considerably from one operation to another. Let's look at one of these.

How to Analyze Humidification

A conventional spray-type humidifier is the simplest of the humidification operations. The usual combination of steps by which it is effected is shown in Fig. 2.

Recourse to the humidity diagram shown in Fig. 3 facilitates the understanding of this operation. Fundamentally, this chart is a plot of humidity vs. temperature. The line marked 100%, or saturation, represents the equilibrium concentrations that will exist in air that is in contact with water of the same temperature. These values are:

$$H = \frac{p^*}{1 - p^*} \times \frac{18}{29} \tag{8}$$

where H is in units of pounds of water vapor per pound of bone-dry air and p^* is the vapor of the water in atmospheres. This line is readily established from temperature-vapor pressure data. Water is used in our example but similar diagrams may be prepared for other materials.

Some confusion and conflict, particularly in nomenclature, exist in describing unsaturated air. Even though the water vapor may be at a partial pressure p that is less than its equilibrium vapor pressure p^* at the temperature of the mixture, its absolute humidity is still defined by Eq. (8). Hence:

$$H = \frac{p}{1 - p} \times \frac{18}{29} \tag{8a}$$

However, two alternative terms are used to compare this value with that for saturated air at the same temperature. One is most commonly called percentage humidity and is $100(H/H_{satn.})$. It follows from this definition that, at a specific temperature, humidity and percentage humidity values are proportional. This is not true for the alternative term that is usually designated as percent relative humidity and is defined as $100(p/p^*)$.

By combining these definitions with Eqs. (8) and (8a), we can show that air of a specified absolute humidity has a relative humidity that is greater than its percentage humidity by the ratio:

$$\frac{R.H.}{P.H.} = \frac{p/p^*}{[p/(1-p)]/[p^*/(1-p^*)]} \times 100 = \frac{(1-p)}{(1-p^*)} \times 100 \tag{9}$$

Therefore, the ratio is greater than 1 for unsaturated air ($p < p^*$); equals 1 for saturated air ($p = p^*$), both values being 100%; and equals 1 for bone-dry air ($p = 0$), both values being 0%.

In Fig. 3, the lines that cross the relative humidity with a negative slope are the adiabatic saturation lines. They represent the temperature-humidity path that unsaturated air will follow if contacted with water of the temperature indicated at the intersection with the saturation line. Under these circumstances, the temperature of the water does not change and the enthalpy of the air remains constant. Since Ldt is zero, Eq. (2) shows that the heat to vaporize the water is quantitatively obtained as sensible heat from the humid air:

$$dN = w'\,dH$$

$$d\,(q_{sens.})_g = w'\,(C_{air} + HC_{wv})\,dt \tag{10}$$

$$dH = -\,(C_{air} + HC_{wv})\,dt \tag{10a}$$

The adiabatic saturation lines are linear if we con-

sider: (1) latent heat constant; (2) sensible heat, required to heat water vapor from saturation temperature at which it vaporizes to air temperature, negligible; and (3) heat required to heat 1 lb. of bone-dry air plus the water vapor it contains, independent of humidity.

Only at relatively high temperatures and humidities is the curvature of these lines perceptible as required by Eq. (10a), which shows their slope to be $-(C_{at} + HC_{wv})/\lambda$. The term in the parentheses is called the humid heat of air, C_H.

Humid heat of air is a convenient term to use in calculations since the weight of the bone-dry air remains constant although weight and volume of the mixture change in the process. The humid heat value is usually considered to depend on humidity alone. Hence, it is independent of temperature in terms of the accuracy required by most calculations:

$$C_H = 0.238 + 0.47\,H$$

For the air-water system only, the adiabatic saturation lines coincide with the wet-bulb lines. The latter relate the steady-state temperature that water will attain in contact with unsaturated air of a specified humidity and temperature. The lines indicate all combinations of temperature and humidity that will give the same dynamic-equilibrium water temperature as shown in Fig. 5.

In this sketch, t_w is the one water temperature at which the rate of sensible heat transfer from the gas phase to the water-air interface is exactly equal to the latent heat of vaporization, multiplied by the rate at which the water vapor diffuses from the interface to the gas phase. Expressed quantitatively by Eqs. (6) and (7):

$$h_g A\,(t - t_w) = \lambda M k_g A\,(p_w - p) \qquad (11)$$

Although, for the air-water system, the wet-bulb and adiabatic saturation temperatures have the same value, they have quite different meanings. The wet-bulb temperature is concerned with the temperature the water will attain; and the adiabatic stauration temperature with the temperature the air could attain through contact.

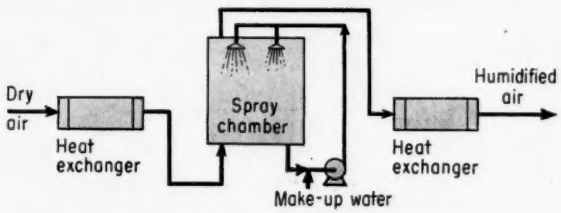
Referring to Eqs. (8) and (8a), it will be noted that for air of low absolute humidity, the partial pressure is negligible as compared with atmospheric, and H is very nearly proportional to p. For air of moderate water vapor content, this is not exactly true but the approximation introduces little error. Accordingly, the proportionality factors may be incorporated in the mass transfer coefficient and Eq. (11) rewritten with humidity difference as the driving force:

$$h_g A\,(t - t_w) = \lambda k_H A\,(H_w - H)$$

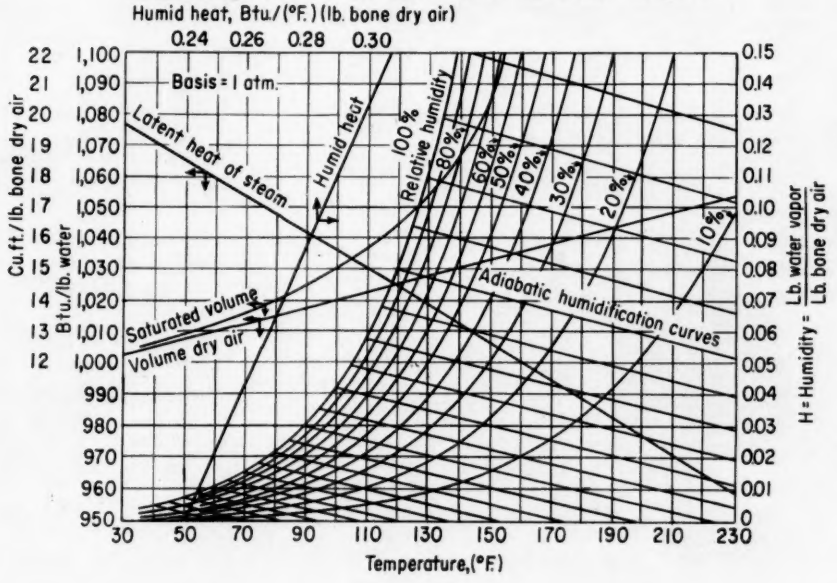
$$H = H_w - \left(\frac{h_g A\,(t - t_w)}{k_H A\,\lambda}\right) \qquad (12)$$

Eq. (12) requires knowledge of the ratio of the

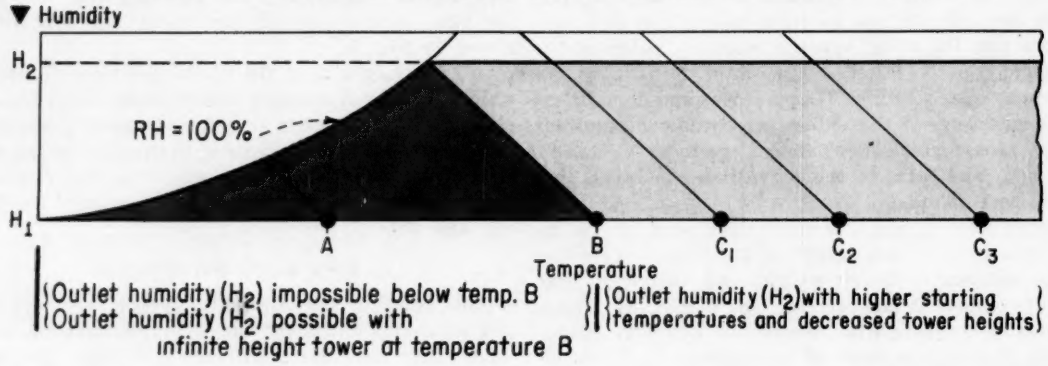
Flow streams in humidifier—Fig. 2



Humidity chart for air-water system—Fig. 3



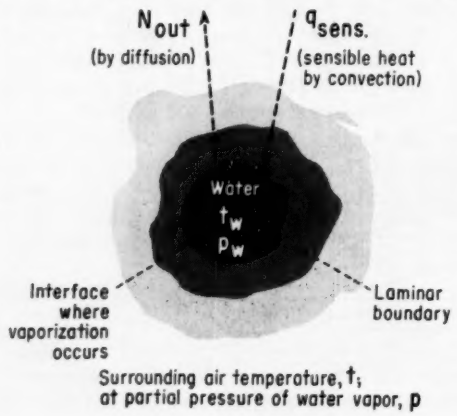
Humidity chart explains reason for air preheat exchanger—Fig. 4



transfer coefficients. Consequently, the group h_g/k_H has been studied extensively. Its value for the system, air-water vapor, is in the order of 0.25, which is substantially the same as the humid heat value. This causes coincidence of the wet-bulb and adiabatic saturation lines (slope of the latter is C_H/λ). For other materials, the h_g/k_H ratio is somewhat higher and the wet-bulb temperature usually proves to be higher than the adiabatic saturation temperature for the same air-vapor mixture.

Eqs. (10) through (12) can be used to express the performance of the spray humidifier quantitatively. Normally, the water is recirculated. This is partially a matter of economy as only a small portion of the liquid is vaporized during any one pass through the spray chamber. Also, recirculation provides higher mass flow rates that, as for other coefficient correlations, result in higher h and k values. With recirculation, the water attains the wet-bulb temperature of the air and does not change in temperature from inlet to outlet. As a corollary, the air temperature and humidity follow the adiabatic saturation line.

Dynamic equilibrium conditions—Fig. 5



The differential statements made in Eqs. (2) and (7), with the substitution of H for p and the corresponding conversion of the mass transfer coefficient in the latter, can be integrated readily:

$$d\,(q_{sens.})_g = -w'\,C_H\,dt = h_g\,a\,S dz \qquad (13)$$

$$Z = \frac{w'\,C_H}{h_g\,aS}\int_{t_1}^{t_2}\frac{dt}{(t-T)} = \frac{w'\,C_H}{h_g\,aS}\ln\left(\frac{t_1-T}{t_2-T}\right) \qquad (13a)$$

$$dN = w'\,dH = k_H\,aSdz\,(H_w - H) \qquad (14)$$

$$Z = \frac{w'}{k_H\,aS}\int_{H_1}^{H_2}\frac{dH}{(H_w-H)} = \frac{w'}{k_H\,aS}\ln\left(\frac{H_w-H_1}{H_w-H_2}\right) \qquad (14a)$$

These equations may be rearranged to the more usual forms:

$$(q_{sens.})_g = w'\,C_H\,(t_1 - t_2) = h_g\,aSZ\,(t-T)_{log\ mean} \qquad (13b)$$

$$N = w'\,(H_1 - H_2) = k_H\,aSZ\,(H_w - H)_{log\ mean} \qquad (14b)$$

Since the height of the tower in which contact takes place is the same whether heat or mass transfer is considered, it follows that the heat and mass transfer coefficients cannot vary independently.

Example Shows Application of Methods

A spray chamber is to be designed to raise the humidity of air from 0.005 lb. water/lb. bone-dry air to a value of 0.014. Flow rate of the inlet air is 10,000 standard cu. ft./min. of bone-dry air.

The chamber will operate adiabatically with the air entering at 140 F. and water being recirculated. Inlet wet-air flow will be 1,000 lb./(hr.) (sq. ft.). At this velocity and for the spray nozzle used, the heat transfer coefficient has been predicted to be 45 Btu./(hr.) (cu. ft.) (°F.). Determine the dimensions of this unit and other pertinent design data.

First establish terminal conditions. Water will attain the wet-bulb temperature of the inlet (and outlet) air of 75 F. The air will follow the adiabatic saturation line to $H_2 = 0.014$, at $t_2 = 100$ F.

Next, make material and heat balances. Using Eq. (14b), we find mass transfer rate N as:

$$N = w'\,dH = \left(\frac{10{,}000 \times 60 \times 18}{359}\right)(0.014 - 0.005)$$

Solving, we find N equals 271 lb. of water vapor to

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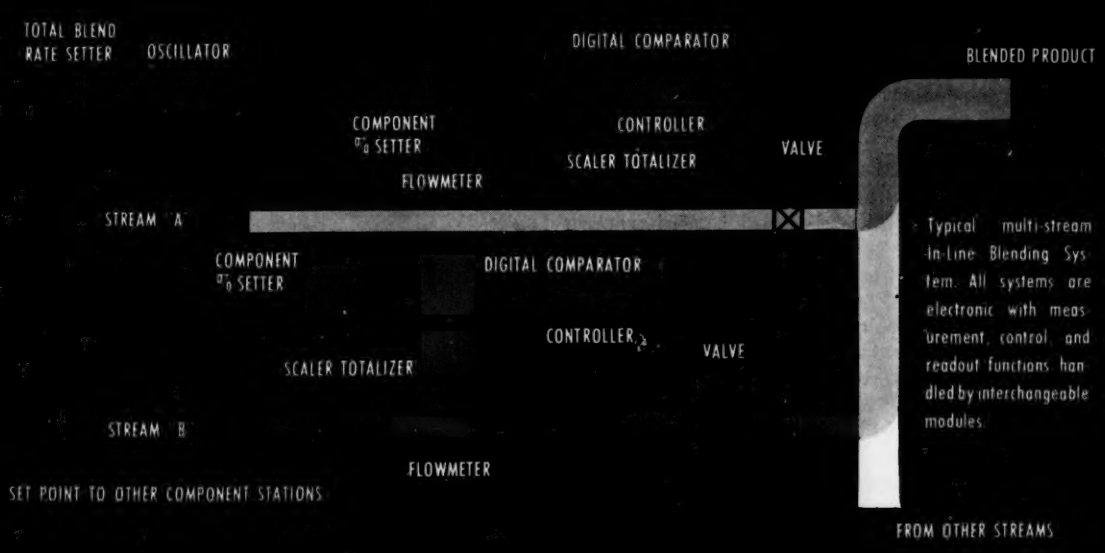

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be transferred between phases. This value also equals makeup water requirements for this unit when operating under the given conditions.

To check the heat balance, use the relation given in Eq. (13b) for the gas-phase sensible heat term and the value of 271 lb. for N, as calculated above, for the latent heat term. Hence:

$$q_{sens.} \cong w\,(C_H)_{avg.}\,(t_2 - t_1) \cong N\lambda_w$$

$$30{,}100 \times 0.245\,(140 - 100) \cong 271\,[1{,}050 + 0.43\,(100 - 75)]$$

$$295{,}000 \cong 284{,}000 \text{ Btu./hr.}$$

This heat balance does not give a perfect check because an average value for the humid heat C_H was used. Also minor errors in reading the temperature at the gas outlet end of the contacting chamber t_2 show up here.

Cross sectional area for flow S equals total flow divided by allowable flow rate. Therefore:

$$S = \frac{30{,}100 \times 1.005}{1{,}000} = 30.2 \text{ sq. ft.}$$

Height of contacting chamber Z is found from the relations given in Eq. (13b):

$$q_{sens.} = h_a SZ\,(\Delta t_{LM})$$

$$295{,}000 = 45 \times 30.2\,Z\,(42)$$

$$Z = 5.2 \text{ ft.}$$

Why Air Preheater Is Necessary

Referring to Fig. 2, note that the purpose of the initial heat exchanger is to provide suitable mean driving forces. If the air leaving the first exchanger were not heated sufficiently (say at temperature A in Fig. 4), the outlet humidity could not be attained even if the exit air were saturated, which Eqs. (13a) and (14a) show would require a tower of infinite height for this starting condition.

Temperature B in Fig. 4 is the lowest temperature to which the air could be heated to attain H_2; and it also would require an infinite contactor. Thereafter, the higher the temperature (C_1, C_2, C_3 . . .), the better the average driving force and the shorter the tower. The second exchanger in Fig. 2 is for adjusting the percentage humidity by altering the final temperature at constant humidity.

Insofar as the design of the spray chamber is concerned, the length of the contact path Z may be its height if the exchanger is vertical, or its length if horizontal. Humidifiers are unique in that the water temperature is constant and thus the mean driving force does not require counterflow for most-effective operation.

The cross sectional area for flow S is dictated by the same two factors that were important in absorber design. These factors are: (1) maximum velocity must be less than that which will cause entrainment, high pressure drop or similar mechanical problems; (2) mass flow rate should be sufficient to give an effective coefficient. In spray towers, the number of nozzles and their design becomes a critical item.

Nomenclature

A	Heat or mass transfer area, sq. ft.
a	Heat or mass transfer area, sq. ft./cu. ft. of contact volume.
C	Specific heat, Btu./(lb.) (°F.).
C_m	Molal specific heat, Btu./(lb.-mole) (°F.).
C_H	Humid heat, Btu./(lb. bone-dry air) (°F.).
D	Mass diffusivity, sq. ft./hr.
G	Gas phase flow rate, lb./hr. or lb.-mole/hr.
H	Humidity, lb. water vapor/lb. bone-dry air.
h	Heat transfer coefficient, Btu./(hr.) (sq. ft.) (°F.).
i	Enthalpy, Btu./lb.
k	Mass transfer coefficient.
k_c	Mass transfer coefficient, lb.-mole/(hr.) (sq. ft.) (mole/cu. ft.).
k_g	Mass transfer coefficient, lb.-mole/(hr.) (sq. ft.) (atm.).
k_H	Mass transfer coefficient, lb.-mole/(hr.) (sq. ft.) (ΔH).
k_t	Thermal conductivity, Btu./(hr.) (sq. ft.) (°F./ft.).
L	Liquid phase flow rate, lb./hr. or lb.-mole/hr.
M	Molecular weight.
N	Mass transfer rate, lb./hr. or lb.-mole/hr.
P	Total pressure, atm.
p	Partial pressure, atm.
p^*	Vapor pressure, atm.
q	Heat transfer rate, Btu./hr.
S	Cross sectional area for flow, sq. ft.
T	Temperature of liquid phase, °F.
t	Temperature of gas phase, °F.
V	Volume of contacting chamber, cu. ft.
w	Weight rate of flow of gas phase, lb./hr.
w'	Weight rate of solute-free gas, lb./hr.
X	Effective thickness of boundary layer, ft.
x	Mole fraction of component in liquid phase.
y	Mole fraction of component in gas phase.
Z	Height or length of contacting chamber, ft.
z	Distance along path of gas flow, ft.
λ	Latent heat of vaporization, Btu./lb.
λ_m	Latent heat of vaporization, Btu./lb.-mole.

Subscripts

0	Reference
1	Gas inlet end of contacting chamber.
2	Gas outlet end of contacting chamber.
g	Gas phase.
i	At interface conditions.
L	Liquid phase.
w	At water conditions.
wv	Water vapor.

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1. Coates, J., and R. S. Pressburg, *Chem. Eng.*, Sept. 5, 1960, pp. 135-140; Oct. 3, 1960, pp. 99-104; Oct. 31, 1960, 109-114.
2. Brown, G. C., and others, "Unit Operations," Wiley, New York 1950.

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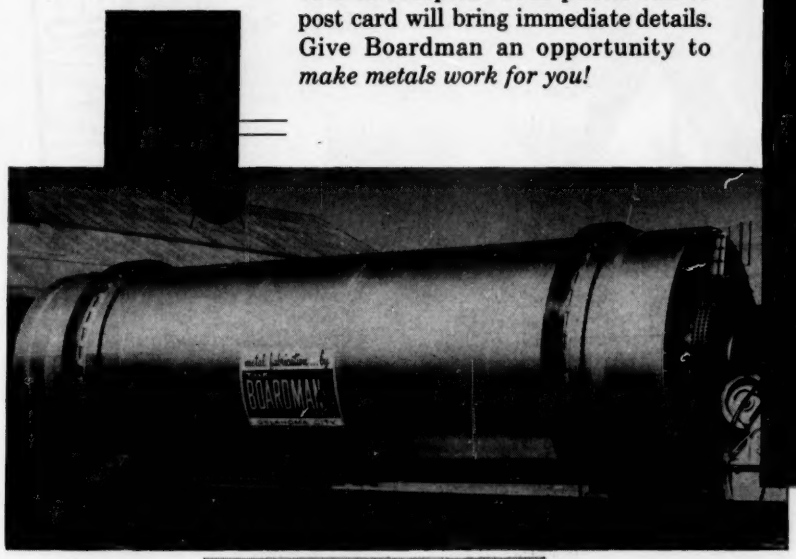

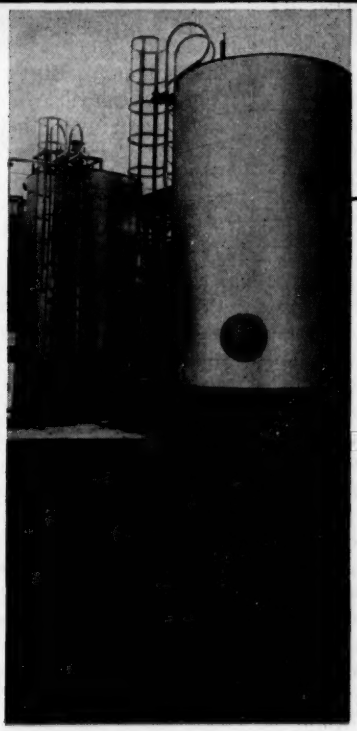

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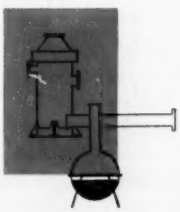

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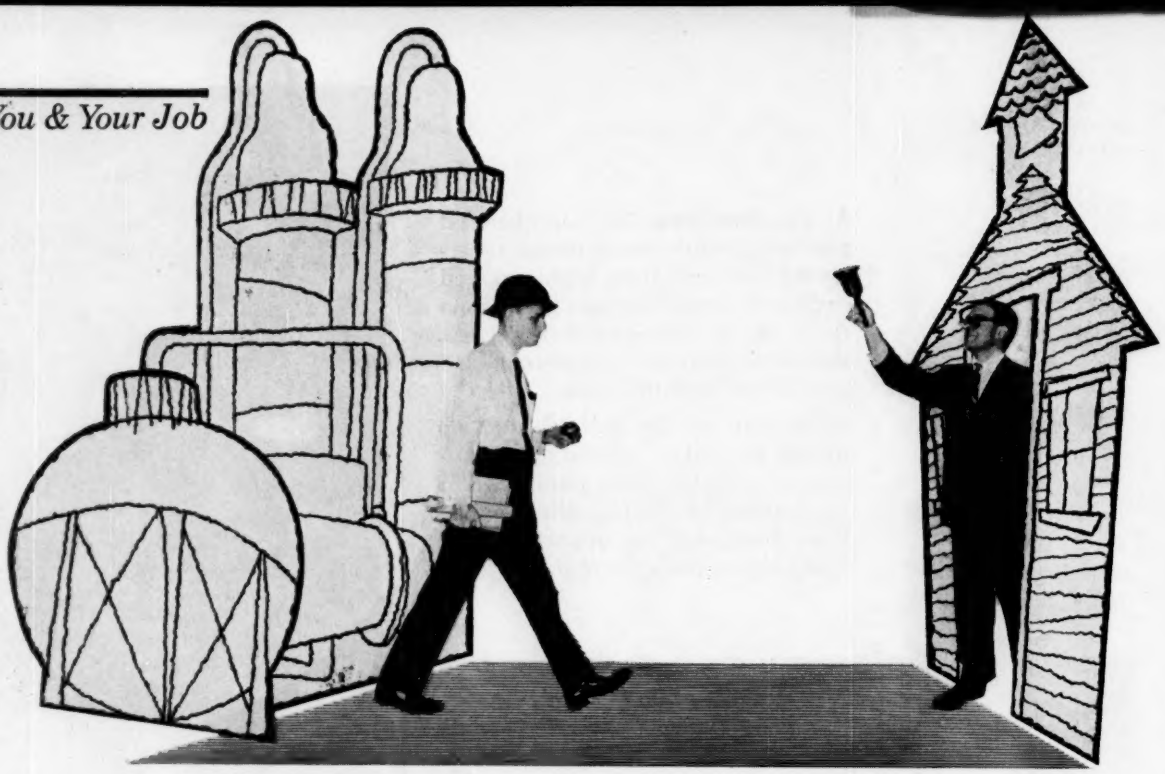


Ten Years Out? Go Back to the Books

"Unless a graduate of ten years ago has systematically spent about ten percent of his time extending his knowledge beyond the level of development achieved in his collegiate training, he will not have value in excess of that of a new graduate. This assumes, too, that he retains all of his previous training, which is probably far from realistic. If decay from neglect or disuse is also ten percent per year, an engineer is then faced with the task of growing in new knowledge at the rate of about twenty percent per year to remain of equal value to his employer and society. To increase in value at a significant rate, he should probably devote about one-third of his productive hours to self-education and improvement. Such growth is a prodigious task. Its magnitude is seldom realized and all too infrequently attained."

*

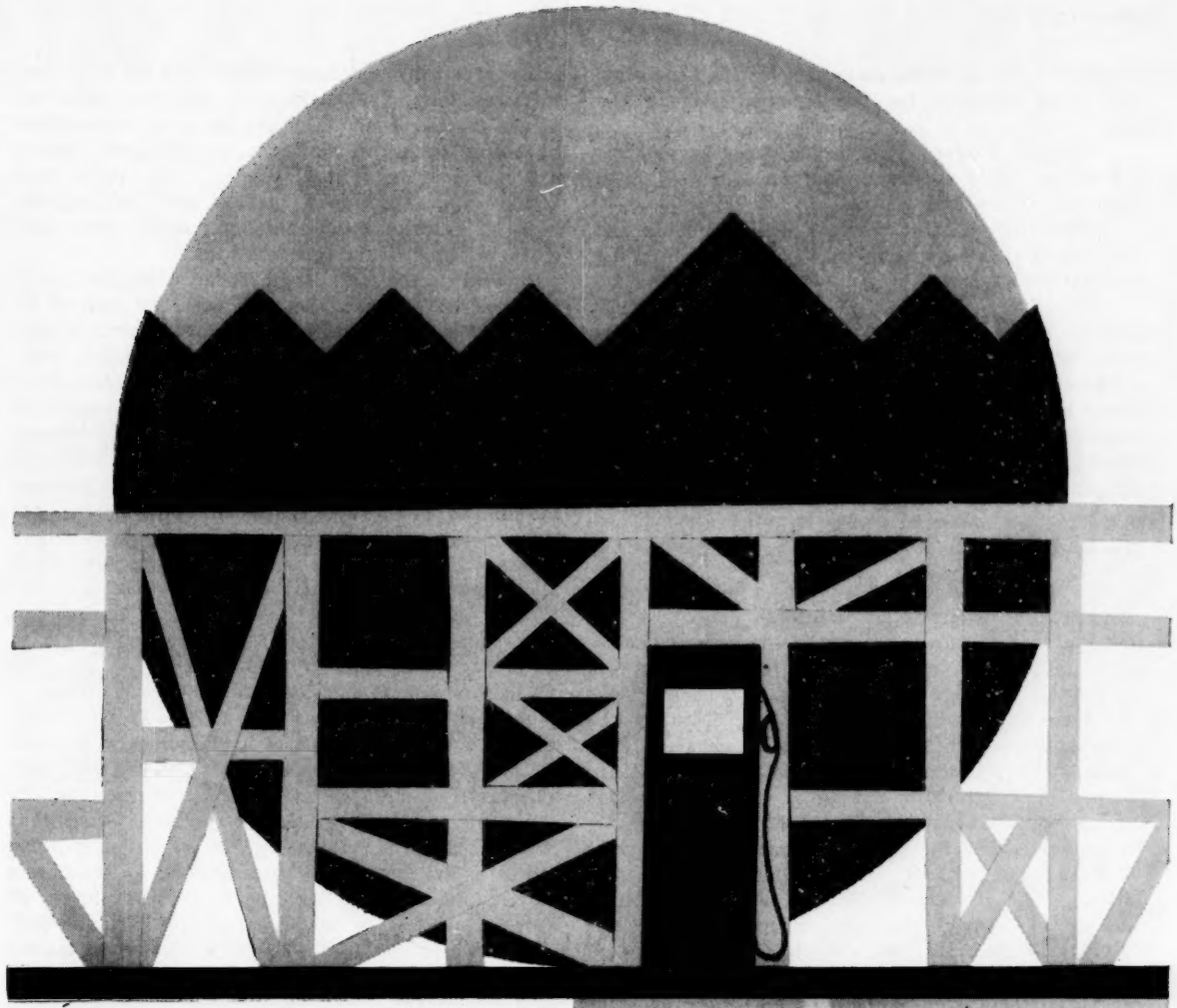
"Nothing is clearer to an engineering educator than that his students who will still be practicing forty-five years hence will be working on devices and with ideas about which he has no knowledge. Thus, above everything else, it is important to educate engineers so that they may continue to grow throughout their professional life. The engineers of the twenty-first century have already enrolled in school."

DR. THOMAS STELSON
in April 1961 "Carnegie Alumnus"

A nearly universal premise of the conferees at last month's M.I.T. centennial meeting in Cambridge, Mass., was that the rate at which scientific and technological knowledge is increasing threatens to overwhelm current methods of distributing that knowledge. The distinguished historian, Elting Morison, who reported on a panel considering interactions of technology and society, emphasized that the ramifications for education are more far-reaching than the technical man may realize.

The historian's report was largely concerned with how "science" can be disseminated to the nonscientist. Most of us are familiar with the pat retort to the accusation that technologists are ill-equipped in the humanities: "Well, what do humanists know of science? Who's really getting the illiberal education"? But invoking this answer overlooks a major part of the problem. If, in this age of technology, the nonscientist must make policy decisions—whether in industry or government—it's important to scientists and engineers that he have some insight into the ways scientists are and science is. (C. P. Snow, of course, has explored this "two-worlds" problem at length.)

Thus it was largely agreed by the panelists, according to Professor Morison, that every educated man should have "some" science. Agreement broke down, however, when the discussion turned to what "some" meant. Lacking agreement on quantity, the panelists sought ways in which education might cope with the



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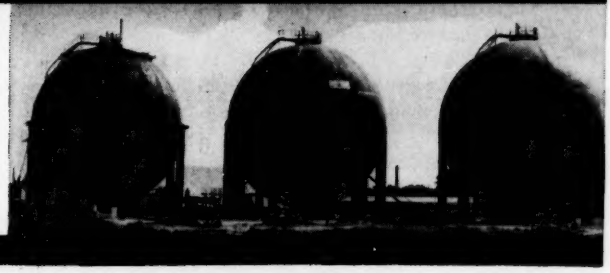

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translation of a growing mass of scientific knowledge into useful insights for the layman. Among the suggestions:

- Within courses on specific sciences, include related materials and ideas that have evolved from other disciplines and studies.
- Establish institutions that draw students and teachers from all nations, encouraging a continuing international dialogue.
- Encourage the study of the history and philosophy of sciences—disciplines that have only recently come into their own.

Examination of these ideas in relation to the educational aims of specific schools might turn up some worthy solutions to ignorance of science, other than science survey courses or a flight from physical sciences to earth and life sciences.

But How Do You Train Engineers?

This facet of the problem of education in a world of expanding technology is of interest and concern to the engineer. But what seems to be the more immediate problem is how to educate engineers in this ballooning universe of knowledge. To chalk out the patterns by which tomorrow's engineers will be cut, another panel at M.I.T. probed two areas that increasingly plague engineering educators: What are we really trying to do now, and what modifications of it are necessary for the future?

An analysis of M. I. T.'s approach to these areas may be found in the thinking of the Institute's engineering dean, Gordon S. Brown. Formerly head of the electrical engineering department, Dr. Brown was responsible for creating a revolution of curriculum revision in that discipline. He was picked to lead M.I.T.'s engineering school several years ago and naturally carried many of his curriculum ideas into the newer post. It's his contention that the wide spectrum of engineering holds essentially three types of worker: The creator, the designer and the custodian of technology. Any "solution" to the problems of education, then, must consider the very different needs of these three.

M.I.T., which has been characterized as a university polarized around science, doesn't see its primary mission as encompassing all three engineering functions. It believes the third category, for example, lies outside its historical role. The custodians of technology are represented by the broad base of B.S. engineers who assemble, operate and maintain our industrial plant. Their education will have to be continually upgraded, of course, to meet the demands of more-complex technology, but they aren't the innovators and will not be responsible for conception and design of new plant.

So M.I.T. and some other technical universities will probably concentrate their resources and efforts on the task of training and developing the creators and designers. Professor Morison calls engineering the practice of the organized forcing of technological change, and Dr. Brown has pointed out that intellectual creativity and inventiveness are its dominant characteristics. The engineer is not just applying science to the benefit of man; he must relate what in nature seems unrelated, to provide new, useful and economic industrial systems. And those who conceive and design these systems must be prepared to do so in quite a different environment than that of their fathers and grandfathers.

It used to be that engineering education could be premised on that what an engineer learned in college would endure throughout his technical career. That's no more. It existed because scientists were busy describing what engineers had already done by practice of their art. Once they had overcome this backlog, the scientists began theorizing in unknown areas, and this fluidized what had seemed before to be a cohesive body of technology. The lag between the discoveries of science and the oiling of the machine has been chopped now to where it threatens the economic well-being of the engineer who won't or can't update his skills.

Education for Oblivion?

The more-comprehensive salary surveys of recent years, for example, have shown that in terms of pay, employers place higher value on the younger engineer (*Chem. Eng.*, Mar. 20, p. 172). One educator, Prof. Thomas Stelson, head of the civil engineering department at Carnegie Tech, recently asserted that this will probably continue to be so unless suitable remedies are devised by professional societies, employers and schools. Claiming that the evolution of curriculum at B. S. level is about 10% change each year, Stelson declared today's B. S. graduate has attained the level of proficiency of a M. S. graduate of a decade ago.

This rapid obsolescence of what it taught at undergraduate level has been thought of as a depletion of personal resources. As such, there was a half-serious suggestion at last December's AIChE discussion on dynamic objectives that a tax credit should be allowed the engineer as he gets further and further away from his primary training! Although this loophole might dissolve personal gripes, it obviously doesn't come to grips with the threat of a technology that can't be manned.

As pointed out in a critique of the preliminary AIChE report on dynamic objectives (*Chem. Eng.*, Mar. 20, pp. 166-70), there is no one curriculum that will satisfy the demands of the knowledge explosion, and it is to be hoped that the accrediting committees of ECPD will encourage creative diversification. M.I.T., in looking at the requirements for its own second century, will obviously stress an interdisciplinary approach—one that may ultimately destroy departmental lines. The transmitting genes of this philosophy are already evident in that university's research centers. But beyond that, the school will base its undergraduate program on a close student-faculty association in research, a strong graduate program, and encouragement of a faculty

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Three More Suggestions

And what might other schools do? Of course, each must decide within the specific constraints of its own system, but here are several areas that might be explored:

• Better interchange between business firms and the universities. Although the sabbatical is a fairly well established idea in the universities, and many professors use it to brush up on engineering in industry, there isn't much opposite flow. Industrial firms shouldn't overlook the fact that although older engineers are further from their primary education and, therefore, more "obsolete" than younger men, experience and company loyalty are assets. Why not send technologists back to full-time school every seven years, in special courses to be worked out with the teaching institutions?

• Establishment of part-time schooling for the engineer in practice. Although recent years have seen a great increase in facilities for night courses and even on-the-job university teaching, the response is not near the challenge. Training to keep the engineer apace his profession shouldn't cut deeply into his productive time, but it should be made convenient so that he doesn't waste a lot of his spare time on transportation and waiting for class. And the subjects and teachers should be first-rate.

• A better arrangement of feedback lines between the schools and industrial firms. Many engineering curricula lag because the technological advances made in business get back to the schools in fits and starts. This is a two-way street: management would have to carefully consider the too-easily imposed secrecy of its proprietary projects and rapidly sift out what could be sent back to the universities; on their part, the schools would have to establish aggressive liaison with industrial companies to find out how their environment might affect educational aims.

A NEW LOOK AT ENGINEER ATTITUDES

That title should put you on guard, because—sure enough—engineers have been surveyed again! This latest study,* however, has one advantage: besides its own pulsetaking, it has examined the results of several other studies of the past three years and made some generalizations based on them. The studies:

• J. W. Riegel's "Intangible Rewards for Engineers and Scientists" (University of Michigan, 1958).

• "The Conflict Between the Scientific Mind and the Management Mind" (Opinion Research Corp., Princeton, 1959).

• L. E. Danielson's "Characteristics of Engineers and Scientists" (University of Michigan, 1960).

• "Engineering Professionalism in Industry" (Opinion Research Corp., 1960). See *Chem. Eng.*, July 25, 1960, pp. 127-130.

As the latest study shows, there seems to be a clear-cut pattern emerging from all these studies—one that should be kept in mind by management, engineering administrators and recruiters.

The recent studies have all been characterized by their reliance, to some extent, on "open-ended" questions, i.e., ones that must be answered at length, rather than by choice of classified answers. Those engineers questioned have been relatively few in number because of the time and expense of conducting such studies. In some cases, the samples have been of a special nature. For example, the newest study considers only "experienced" engineers; another sampled only in "leader" companies. Still, the answers seem to be enough alike in these independent surveys to make generalization possible.

* "A New Look at Engineer Attitudes," Deutsch & Shea, Inc., 230 W. 41st St., New York 36, N. Y., 60 pages, $3.50.

What the New Study Shows

There are several unique areas explored in the Deutsch & Shea study, so let's examine them first. Engineers aren't clock-watchers—92% of the respondents spend some of their own free time on problems connected with their work. The median free overtime spent is 8 hr./wk., but 10% spend more than 20 hr./wk., and several said they would put in more overtime if it weren't taken for granted by management.

As for job-changing, 54% of the respondents said there is some reluctance to do so because of resistance to change, inertia, uprooting of home, unknowns of new job, etc. Loss of fringe benefits (pensions, tenure, profit-sharing, etc.) were also cited by 19% as cutting job mobility. An offer of increase in salary alone doesn't necessarily cause a man to move. Though the median increment expected was 20%, it ranged from nothing to twice the present salary.

The study recommends that recruiters keep in mind ten points when interviewing engineers. Among these are:

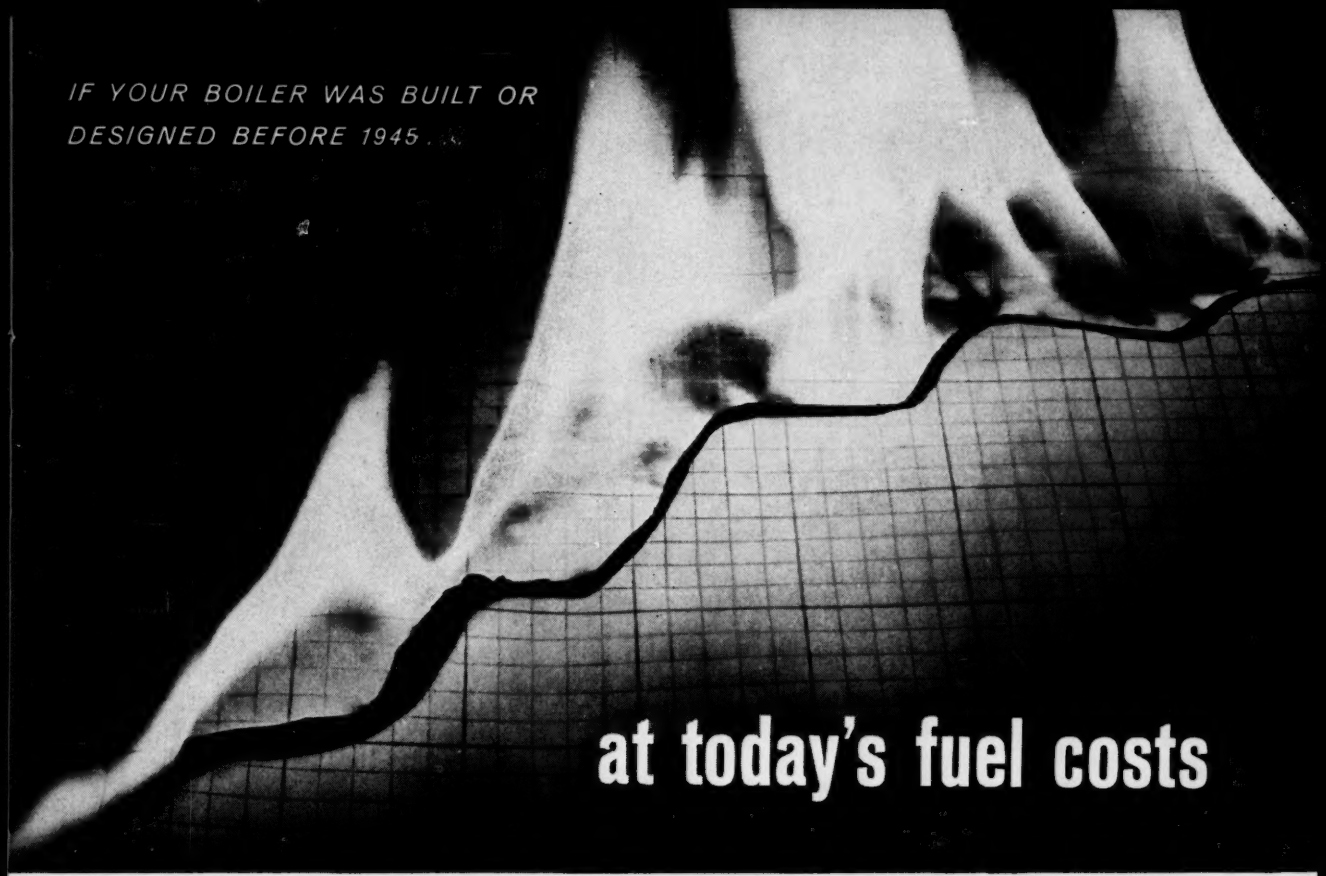
• Offer just a little more detail than usual about specific job vacancies and requirements.

• Convey the opportunity and security in your firm.

• Accentuate job dignity and individuality.

• Don't overstate the case; don't promise the moon.

The study also makes recommendations to managers and engineering administrators. It presents an extensive checklist, based on the attitude studies, to improve manpower utilization, incentives, communications, development and supervision.



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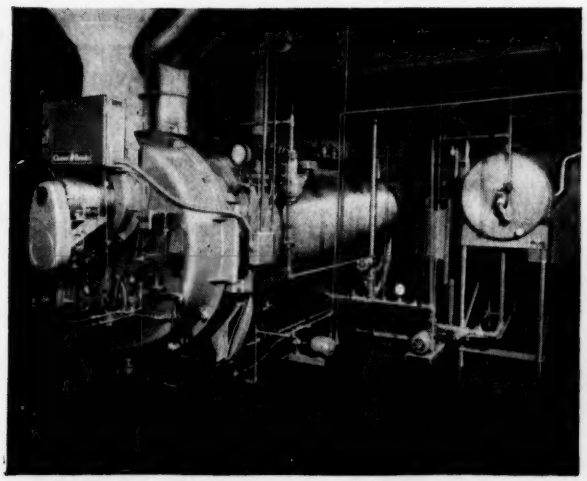

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Are Your Department's Costs Meaningful?

Check charges to your department in detail. You may be the victim of poorly assigned costs or the insidious manipulations of the figure juggler.

WINGATE H. RICHARDSON, *Consultant, New York*

Skulduggery or ineffectiveness in assigning costs to a particular department is more common than outright inventory cheating, which was discussed in a previous article.*

While raw-material receipts and finished goods shipments have to agree with various documents, material transferred from one department to the next sometime goes unchecked. This makes for one form of interplant cost juggling.

Most larger plants have a separate receiving department that is not part of production. In this case, the production sections obtain raw materials from within their own organization and are generally billed for them by the receiving department. There are also many other charges to the individual production sections—steam, water, power, maintenance materials, and maintenance and operating labor. Thus opportunities exist for both honest and less honest mistakes.

One morning near the end of the month, Bill was making a preliminary month-end estimate of our production and yield figures.

"Has Charlie from Receiving called you yet for our estimated-yield figures?" he asked.

"No. Not yet."

"Did it ever occur to you that there's something funny about his interest in our estimated yields a few days before the end of the month?"

"No. Why?"

"Well, it seems funny to me. On the last day of the month, he always calls me up to report errors he's found in his charges to us, and sometimes I've got to add as much as 5,000 gallons to the raw-materials-received figure for the month. The next time he calls how about letting me give him the estimated yield figure?"

(If you have a good crew they will take good care of your interests if you allow them to do so. So I said OK.)

Well, of course, Charlie got a very low yield estimate from Bill. Charlie's compassion evidently spilled over into his charges to us, for when the month ended we were able to report one of the best actual yields we ever had. Needless to say, this alerted us to the necessity of keeping accurate records of our own and thereafter we always took stick readings of our feed tanks before and after receipt of material. Quantities received were verified immediately with the raw-materials department and if there was any disagreement it was resolved then—not at the end of the month. To make sure none of the material charged to us ended up in someone else's feedtank, we also found it necessary to "run the header" from the tank farm from end to end, and to close all open valves. Strangely enough, we frequently found that the valves between the header and the feed tanks for the other departments were not completely closed.

We never came to any firm conclusions for the obvious juggling of the raw-materials figures but there are several possibilities. The raw-materials department may have wished to prorate its handling losses, whether they were normal losses such as those due to evaporation, or abnormal losses due to spills, leaks, or careless car unloading. This plant had a number of duplicate operating lines, and the competition for good yields,

* *Chem. Eng.*, Nov. 30, 1959, p. 104.

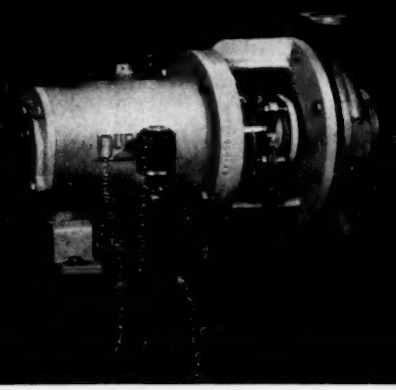
HNO_3

H_3PO_4

HF

H_2SO_4

HCl



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whether natural, desperate, or due to abnormal ambition, may have been a factor. In any event, the figures obtained were distortions of the facts, and the location and cause of losses was being concealed. This is obviously very poor operating practice.

Labor costs also bear watching. A shrewd department manager may be very adept at "borrowing" a little extra help from another department or arranging for maintenance time that is charged to another operation. This is usually done when he has an "emergency" —and if his "emergencies" do not occur too frequently, it is not a serious problem. Conversely, he may "lend" his help to you, at your expense, during periods when his operations have been shut down temporarily for repairs, lack of business, or for any other reason. If you can use the extra help efficiently, well and good. If not, you are merely charging his losses due to down time to your operations. If you are watching costs closely, these are items that should not be overlooked.

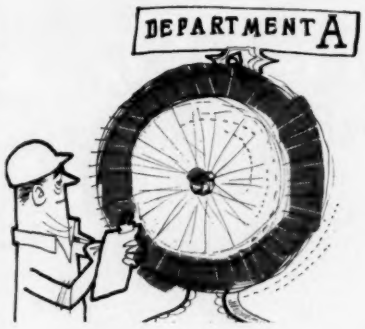
Unrealistic Costs Are No Joke

Sometimes the juggling of materials usage can lead a plant close to economic disaster. With a new product everyone is cost conscious. Every effort is made to keep actual operating costs at a minimum, and there is a great temptation to push the calculated cost figure down still further by cutting a few corners.

Some years ago, I worked in a textile coating plant that had developed a new line of shade cloth. This was a high-quality item and commanded a premium price on the market. The specifications were difficult to meet since the cloth had to be free of imperfections when viewed in either transmitted or reflected light. There was no opportunity to cover a defective run with a second or third coat. The accounting department established very low limits for the quantity of downgraded material allowed. With costs closely watched and the inspection department operating at 100% efficiency in detecting flaws, life became a little difficult for the production department. So, what to do?

Without getting involved in details, production found it could easily meet the requirements of the inspection department by overcoating, i.e., using more material than allowed for by the accounting department. The extra material used was charged off to the coating of heavy goods, a multicoated product with an established market, the specifications for which were not so difficult to meet. Thereafter, operations were carried on with the happy philosophy that what the accounting department didn't know wouldn't hurt it.

Then came the day when our principal customer for heavy goods was shut down by a strike and the



production of that item practically ceased. No one was too worried about this drop in business since the demand for our new product had been increasing steadily. In the following month, our production hit an all-time high despite the cutback in heavy-goods production. This was the inevitable day of reckoning. The accounting department discovered that in our best production month . . . we had operated at a loss.

The solution? A hurried telephone call to a firm of management consultants. This organization periodically reviewed our operations, revised our accounting procedures and established new operating and inspection procedures. They had left us with new operating instructions, including a set of standard report forms for reporting each department's operations. I still remember the day a member of this team of experts came into the production department and asked to see our coating specifications. He was somewhat stunned when the clerk blithely asked: "Which specifications do you want? Those that we use in our coating operations or those that we give to the accounting department to figure costs?"

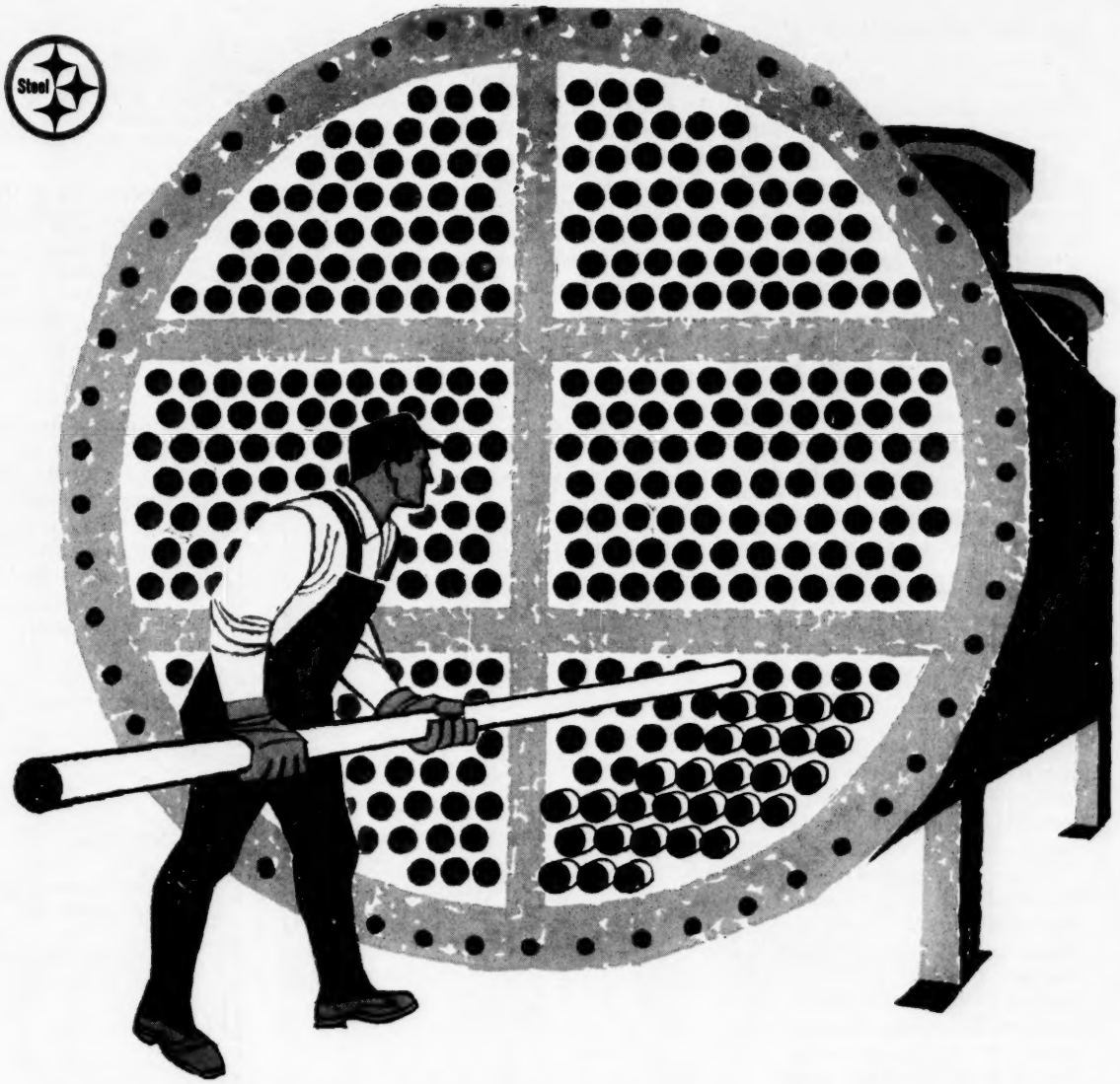
Lumping Together May Mislead

In small plants, cost accounting procedures are often woefully inadequate. Small items of expense, and sometimes large items not directly chargeable to a single product, are often carried in a general overhead account and prorated among a number of items produced. There are two serious difficulties in this.

First, you have lost control of your costs; for if you don't know what a cost should really be charged to, you don't know whether it is a necessary expense or not. Second, you can never be sure that your costs are properly distributed.

In one of those gloomy periods of declining business, it became obvious that our costs were out of line on one of our bread and butter items. A careful analysis of our cost breakdown for this item showed that the cost of steam charged to the operation might be excessive. We had no way of knowing what the steam consumption actually was. All charges to the steam plant were prorated among the various operating departments each month on an arbitrary basis.

It had been common practice in the past to change the ratios used in prorating steam costs among the various operating departments. Actually this was a useful and fascinating gimmick. When the home office called with a complaint about manufacturing costs on a specific item, we had a ready answer: "Oh, our accounting department has probably goofed on the steam costs. We will check and call you back." We always found that we had charged too much steam to the item and an adjustment was made to bring costs down. Of course, we had to add the charges to some other product but this would not be picked up at the home office until the next month. If



How to prevent corrosion when the pressure's on

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Jones & Laughlin Steel Corp., Electricweld Tube Div. ↓
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Ohio Seamless Tube Div., Copperweld Steel Co. ↓
Republic Steel Corp., Steel and Tubes Div. ↓
Revere Copper & Brass Inc., Rome Mfg. Co. Div. ↓
Sawhill Tubular Products, Inc. ↓
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The Standard Tube Co. ↓
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WELDED STEEL TUBE INSTITUTE, INC.

we were in luck, it wouldn't be picked up at all, but if it was, the same procedure was followed again.

In periods of rising prices this works just fine. Your operating losses are covered by your gains on inventory values—but in periods of decline, there comes the inevitable day of reckoning:

So we installed steam flow meters, and asked the accounting department to give us the cost of steam per 1,000 lb. each month. A month later, I got quite a shock. Accounting informed me that our steam costs were $1.75 per 1,000 lb! We had an inefficient steam plant, but even so $0.65 per 1,000 would have been high. So, what was the trouble? As it turned out, there was quite a lot of trouble.

The steam account had been one of those happy catch-all overhead accounts.

First, the labor costs were excessive. This was in part due to the shrewd observation of one of our maintenance contractors that he could supply a considerable amount of nonproductive labor to the steam plant without detection.

A second unhappy observation was that our water consumption was excessive. We found that corroded tubes in the feedwater preheater diverted a considerable amount of feedwater from a municipal water system directly to the sewer. We also uncovered a number of lesser items of useless expense that added up to an impressive total.

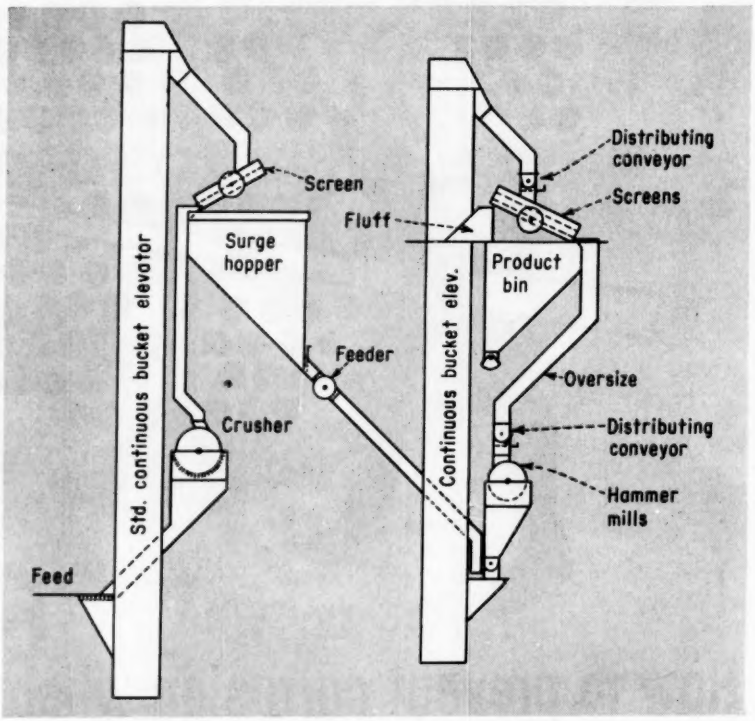
A considerable overhaul of our operating procedures in the steam plant was necessary. No amount of juggling the ratios by which these costs were charged to the various operating departments would eliminate the basic trouble—careless and inefficient operation of the steam plant.

It will pay to check charges to your department in detail. In general, the accounting department will not know whether the costs are legitimate or not. This is your responsibility. Large items may be used to conceal unnecessary expense on the theory that the percentage difference will not be noticeable. Small items may be included on the theory that little attention is paid small amounts. Irregularities may be rationalized by the claim, "What difference does it make? It all comes out of the same pocket anyway."

None of these arguments are valid. If you want to operate at a profit, you must know what your costs are. You can then make sure that they are legitimate and that they are kept to a minimum.

This is the eighth in a series of articles on practical operations by an experienced operating man. Previous articles:

Temperature Control	**Sept. 21, 1959**
Inventory Cheating	**Nov. 30, 1959**
Specifications	**Feb. 8, 1960**
Salesmen	**May 2, 1960**
Safety	**July 11, 1960**
Stealing	**Oct. 17, 1960**
Manufacturing	**Jan. 9, 1961**



ARE YOU GETTING THE MOST OUT OF CLOSED-CIRCUIT GRINDING?

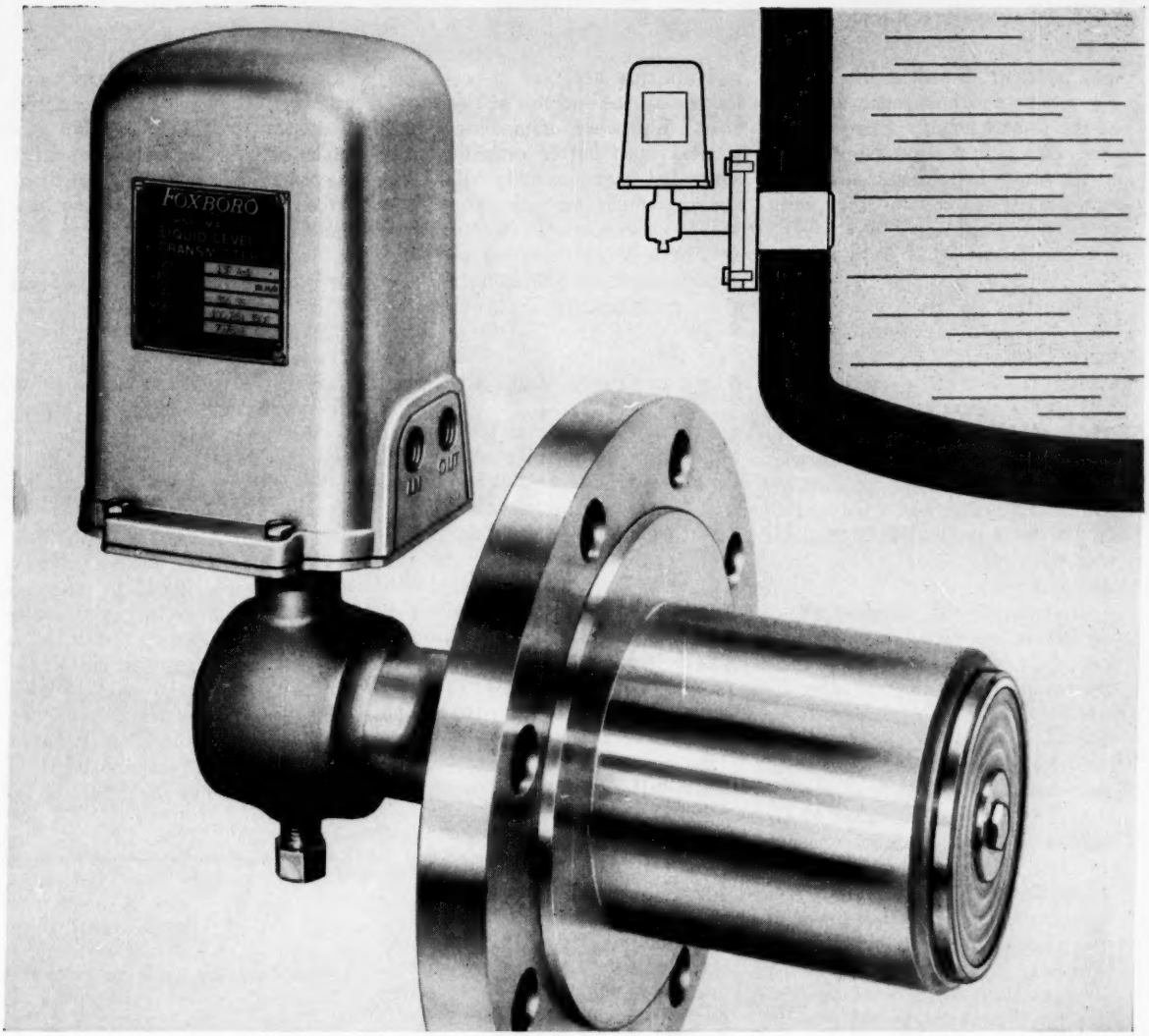
Greater division of functions can increase production while reducing power and labor requirements.

CHESMAN A. LEE, *U. S. Steel Corp.*

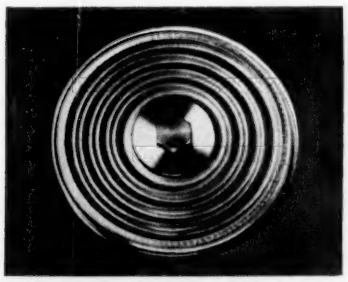
In closed-circuit grinding, cushions of material inside the crushers or grinders are neither necessary nor desirable.

Much has been written in favor of the closed-circuit system—indeed it has often been called the fundamental requirement for grinding efficiency, although its cost is relatively high for small capacities.

Experience has convinced me, however, that many engineers are still not fully aware of just how



introducing Foxboro's new extended diaphragm liquid level transmitter... designed especially for thick-wall tanks



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The sensing diaphragm capsule extends right through tank walls and lagging — up to 6 inches. Troublesome, catch-all pockets are eliminated. No chance for solids to build up — no need for purging or cleaning.

And you'll find the T/13 FA "extended diaphragm" d/p Cell just as reliable as the standard Foxboro flange-mounted transmitters. Direct 3-15 psi air output signal (no need for intermediate signal converters) . . . accurate, troublefree. Ideal for viscous or corrosive fluids, slurries, and solids in suspension — as well as easy-to-measure fluids.

Write for Bulletin 13-22. Or ask your nearby Foxboro Field Engineer for all the details. The Foxboro Company, 365 Neponset Ave., Foxboro, Mass.

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very efficient closed-circuit grinding can be and how much depends on the proper amount of recirculation. As a result, many plants have either avoided a closed-circuit system, or are not getting maximum production from it.

The latter was the case in our installation for grinding degreased fat residues. While we considered the existing setup reasonably satisfactory, we wanted to increase production further and eliminate some bottlenecks that required extra labor. At first, we thought extra equipment would be the answer, but by the time we had finished, we had actually taken one attrition mill out of service, while solving the bottleneck and doubling our production.

The well-meant suggestions of equipment manufacturers did not help us too much in making these improvements. The suggestions were based on industry experience, and as it turned out, some of this experience was based on misconceptions.

Our installation consisted of two separate closed circuits connected in series, as shown in the sketch. In the first circuit, the output from the crusher was raised to the scalping screen by a standard bucket elevator. The oversized tailings dropped back to the crusher, while the fines were fed to the grinding circuit. The speed was controlled by a variable speed drive.

The crusher itself was "slugger" type, with heavy hammers, a rugged breaker plate and a cage made up of cast-steel bars in the bottom. It was well constructed, but we frequently had overloading troubles. The circuit breaker would trip and we would have to clear the mill. After turning the shaft over several times, we were usually able to start up again. Since the surge hopper continued to feed, we lost no production; however, the extra attention imposed a drain on our manpower and supervision.

The crusher cage held back a bed of material. Some of this would be swept up by the hammers and bounced around again. Other material would be crushed by pressure. We thought that perhaps there was too much cushion effect when material hit this bed, and hence tried increasing the spacing of the cage-bars. We were immediately rewarded with better crushing and somewhat more capacity. Keeping the mill empty was paying off.

We were now able to install a smaller mesh cloth on the scalping screen, thereby throwing more work on the crusher. This left less work for the grinding circuit.

Same Approach Helps Grinding

This circuit included two swing-hammer grinding mills and an attrition mill. The vibrating screen was fed by a bucket elevator. Fines fell through to the product bin, while tailings went back to the grinders. The latter were supposed to work on the shredding principle, and had blades made of flat steel. The bottoms of the grinders were fitted with curved perforated screen-plates. Hole diameter had no relation to product size, but was determined on the basis of keeping the mill loaded up and thereby supposedly doing more work.

As we were doing our best crushing when there was no cushion of material in the mill, we wondered if the same might not hold true of the grinding phase. Perry's "Chemical Engineers' Handbook" encouraged us in this belief. In the book's section on classification, Anthony Anable points out that a mill is better for grinding than for classifying, and that increasing the recirculation increases the amount of actual grinding, and decreases the cost per ton.

Hence, the first step was to use larger perforations in the internal screens of the grinders. This did indeed increase the capacity; but it put too much strain on the conveyor setup. We then speeded up the conveyors and installed larger motors. As the conveying horsepower was still small compared with the grinding horsepower, we had still progressed. Next, we interlocked the drive for the rotary feeder with an overload protection for the conveying system. At this point, we found that we could maintain the increased grinding rate very smoothly without using the attrition mill, so we took it out of service.

Of course, there were many small problems uncovered during our investigation but their solution was incidental. As far as management was concerned, we had not only doubled our production and reduced our connected horsepower, but we had also improved the product by making it less dusty and more uniform in size.

The basic principle involved was of course the division of functions. A crusher is designed for crushing and not for classification. It does its best work when almost empty. This also holds true for grinding mills—with an empty mill, size reduction is by impact rather than by attrition.

The foregoing should suggest ways of recognizing if the screen or cage-bar openings are sufficiently large in other installations. If the mill ever chokes up, or if part of the product is needlessly fine, the holes are probably too small. If in doubt, try a larger-size opening, maintain the same rate of feed, and see if the ammeter readings for the motor are reduced.

Meet the Author

CHESMAN A. LEE *is currently with U. S. Steel's general engineering group at Chicago. His engineering experience has been long and varied, including fertilizer plant construction, heavy mill equipment troubleshooting and conveyor design.*

•

Plant Maintenance Show

The increasing complexity of plant upkeep will be the theme of the Western Plant Maintenance and Engineering Show and its concurrent technical conference, to be held at the Los Angeles Pan Pacific Auditorium next July 18-20. Exhibitors and lecturers will deal with many aspects of the modern plant—its insulation, lighting, heating, air quality, furnishings, cleanliness and safety, as well as equipment maintenance techniques.

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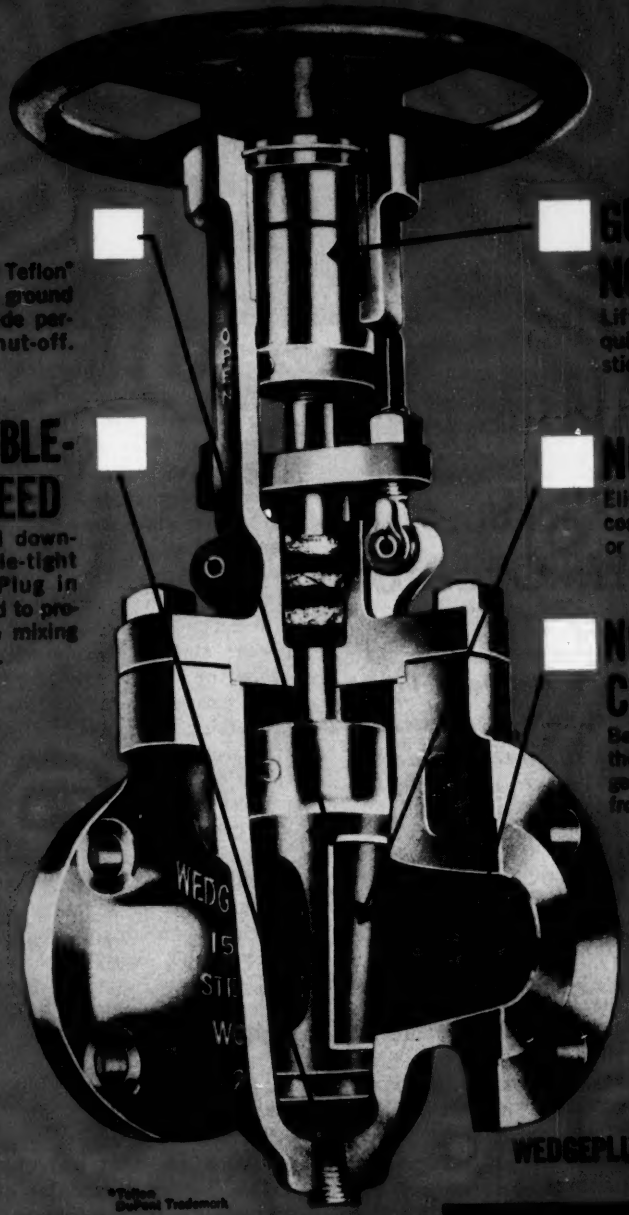

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Try Ceramics for Resistance to Corrosion, Erosion

A review of ceramics that may be used in process equipment, with emphasis on a new product—"KT" silicon carbide.

M. F. KIACHIF
The Carborundum Co.

In the process industries, the materials-of-construction problem is complex because severe conditions of corrosion, erosion and high temperature are often combined.

Metals, ceramics and plastics each have outstanding properties for specific conditions. The challenge to the design engineer is to find the material with the optimum combination of properties for a given set of severe environmental conditions.

Ceramics have long been used as corrosion and erosion-resistant materials of construction. Generally, they are very hard, which leads to exceptional erosion or abrasion resistance. Further, they are rather nonreacting over a wide temperature range, and consequently exhibit excellent corrosion resistance. The uses of glass are well known in piping and in lining of process equipment, as are the uses of porcelains and alumina and alumina silicate bodies as thread guides and nozzles, and of cobalt-bonded tungsten carbide in severe wear applications. Carbon or graphite, though not often considered a ceramic, is widely used in corrosion-resistant heat exchangers.

Until very recently, most wear- and corrosion-resistant ceramics were two-phase bodies—a hard inert ceramic bonded by a less hard and less corrosion-resistant bond. Their properties are almost always limited by the properties of the bond.

A second ceramic group, like many aluminas, are porous sintered bodies with a density substantially below the specific gravity of the material itself. This high porosity results in bodies with low mechanical properties compared with properties of the single-crystal material, with low thermal conductivity because of the insulating pores, and with poorer corrosion resistance due to increased surface and to intergranular attack.

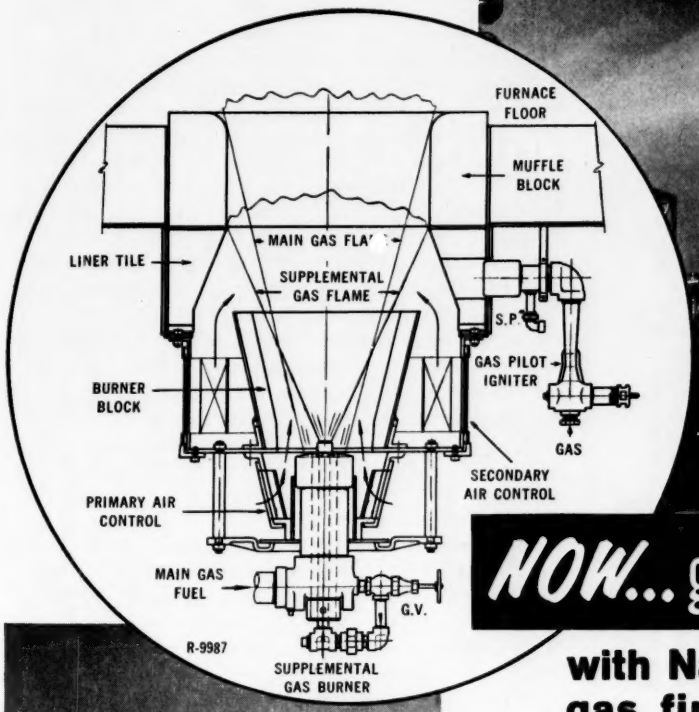
Accelerated by the demands of the rocket and missile field, new technology in ceramics is centered on development of self-bonded, high-density bodies in which the maximum properties of the base material are available in usable shapes.

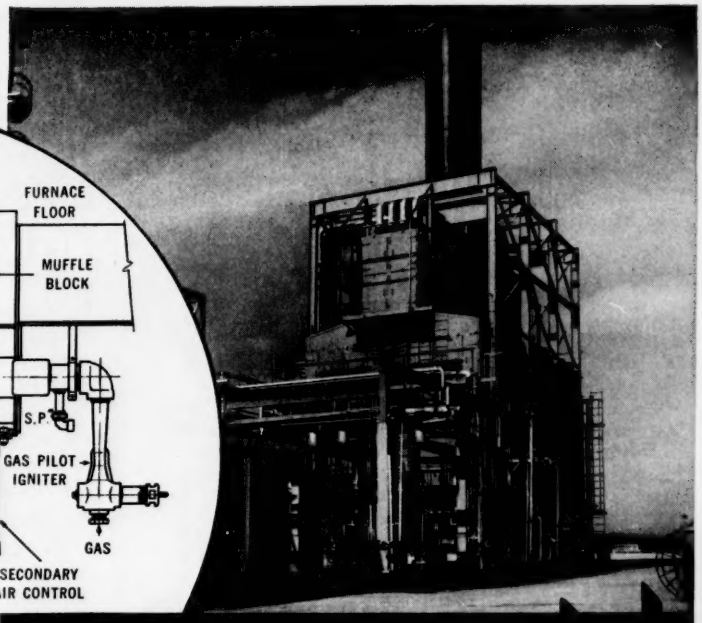
Also, a dramatic improvement in strength can be obtained by a much finer grain size and a much higher purity of raw material.

Among the corrosion-, erosion- and oxidation-resistant ceramics, the following groups are receiving increased attention:

▶ **Borides**—Refractory borides are strong, hard, oxidation resistant and chemically stable. Recently a TiB_2 having a modulus of rupture of 35,000 psi. between room temperature and 3,600 F. has been developed. This material has unusually high electrical conductivity for a ceramic and offers the potential of dramatically improved collector bars for aluminum pots.

▶ **Beryllides**—Beryllides are a relatively new class of high-density ceramics. In addition to high strength and oxidation resistance for temperatures up to 2,950 F.,





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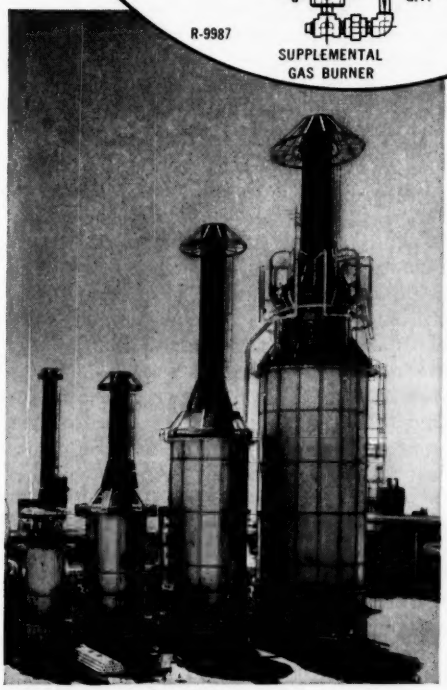

Throughout the world . . . in chemical, petroleum, process, pipeline and related industries, National Airoil CHEMICAL-PETROLEUM up-firing burner units are achieving widespread field acceptance. And for good reason!

In accordance with our continuing policy of product improvement, the present design of this gas firing unit (now in actual quantity use) offers several time-and-money-saving "first time" features:

- An increased proportion of combustion air can be induced, partially independent of stack-furnace draft.
- Thorough mixing of the combustion air can be obtained with a minimum of O_2 in the stack gases. Result: high thermal efficiency; maximum radiation heat transfer.
- Capability exists for changing to different gases with some variation in specific gravities and calorific value to maintain approximately the same gas fuel pressures and heat release.
- Proper flame outline can be obtained relative to the furnace dimensions and proximity of tube surfaces.
- An absence of flash or burn back within the burner casting when firing hydrogen-rich gas.
- Regulation ease and capacity flexibility are assured.

National Airoil C. P. gas units can be supplied with a medium pressure gas pilot for electric ignition. A sufficient range of sizes is available to handle standard capacities. A similar National Airoil design also can be furnished for *oil only*, for *combination gas and oil*, or for *forced draft*.

Literature on these versatile C. P. burner units, together with technical and engineering data is available. Why not write for it *today* while you're thinking about it?

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Corrosion, in acids, of "KT" silicon carbide —hardest material available in shapes

Acid	Concentration (%)	Temperature (° C.)	Time (Hr.)	Average Rate, Mils/Yr.†
HCl	20	Boiling	1008	0.1
	20	175*	144	−0.1
	20	200*	144	0.3
	20	225*	144	0.5
	37	Boiling	144	0.0
HNO_3	30	Boiling	144	0.2
	50	Boiling	1008	0.0
	50	200*	144	4.0
	70	Boiling	144	0.2
	70	225*	144	1.0
H_2SO_4	60	Boiling	144	0.0
	60	200*	144	−0.3
	80	Boiling	1008	−0.1
	95	Boiling	144	−0.8
	95	200*	288	−0.2
	95	225*	144	1.2
H_3PO_4	60	Boiling	1008	0.0
	60	200*	144	−0.1
	85	Boiling	144	2.3
	85	225*	144	0.1

"KT" silicon carbide in various environments

Media	Temperature (° C.)	Accumulative Time (Hr.)	Average Rate Mils/Yr. Accumulative†
10% Na_2SO_4	Boiling	288	0.2
10% Na_2CO_3	Boiling	144	27.6
		432	6.3
		720	−0.4
		1008	−3.4
25% NaOH	Boiling	144	73.3
Fused NaCl	900	24	−3.1
		72	1.3
Fused $MgCl_2$	900	24	49.8
Fused KCl	900	28	107
CO_2	1000	72	24.4
		144	11.4
		216	7.4
Air	1000	72	−0.3
Steam	1100	80	−7.4
H_2	1000	72	−0.4
Dry Cl_2	200	24	2.7
		72	0.2
		192	0.1
	400	24	2.9
		120	0.9
		336	0.9
	600	24	1455
		264	175
		480	111
	800	6	7405
Wet Cl_2	200	6	0.0
		24	0.0
		120	−0.1
	400	48	2.4
		192	1.0
		264	0.6
	600	48	105.6
		192	27.8
		264	20.2

* Under pressure.
† Minus M. P. Y. rates indicate weight gain.

the beryllides offer future possibilities of yielding locally in regions of high stress concentration.

► **Graphite**—The strength to weight ratio of graphite is higher in the temperature range from 3,100 F. to 5,500 F. than that of any known material. To expand the usefulness of graphite at higher temperatures, oxidation-resistant coatings of silicon carbide, capable of use at 2,900 F., have been developed.

► **Carbides**—Refractory carbides have the highest melting points of any class of materials. Modulus of rupture values of 18,000 psi. at 4,000 F. have been obtained. Most carbides, however, are subject to oxidation at very high temperatures; for example, maximum working temperature for B_4C in oxidizing atmosphere is approximately 1,000 F. With the exception of silicon carbide, none of the carbides have good thermal shock resistance under extreme conditions. Work has been started to determine the effect of factors such as grain size, orientation and porosity on strength and thermal shock resistance of the refractory carbides.

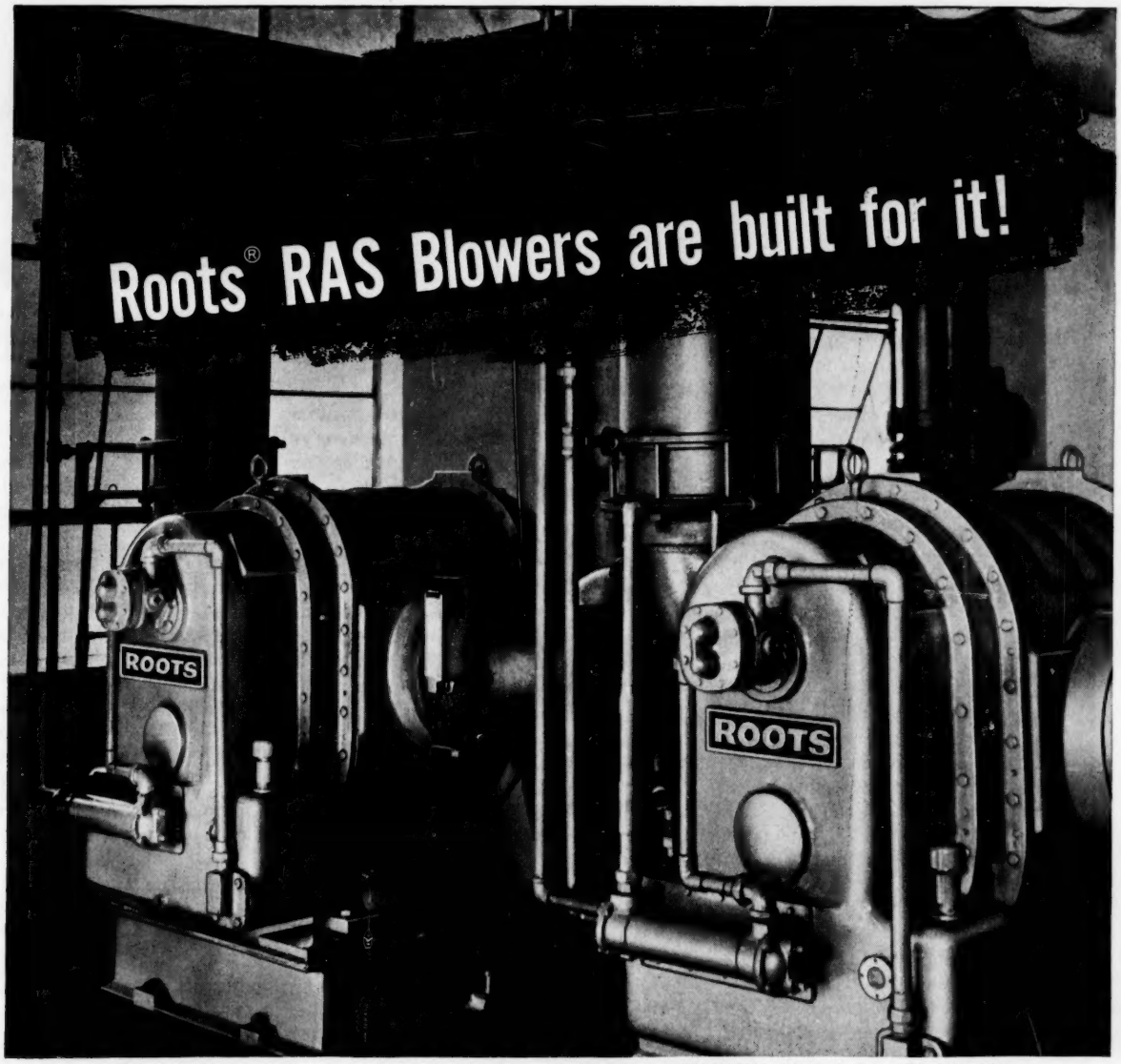
► **Nitrides**—Of the refractory nitrides, hexagonal boron nitride, having a graphitelike structure, shows the most promise. Boron nitride is an electrical insulator, has good room temperature and very good high-temperature strength, excellent thermal shock resistance and low density. It also has the unique property, for a ceramic, of being easily machined. Aluminum nitride, a new strong ceramic, resistant to molten iron, also is receiving increasing attention.

► **Silicides**—The outstanding property of the disilicides is good oxidation resistance. The best known of this group is molybdenum disilicide, which has been used as an oxidation-resistant coating and as a constituent of resistance heating elements that can operate at 3,000 F. in an oxidizing atmosphere.

► **Oxides**—Oxides are extremely stable in air at temperatures of 4,500 F. to 5,400 F. They are the most widely applied refractory structural material. Oxides do not retain strength at high temperature and are poor in thermal shock resistance. It is expected that significant improvements in properties and usefulness of the oxides can be obtained by better processing methods.

► **Glass-Ceramics**—There is a new field of fine-grained crystalline materials made from glass called glass-ceramics. The best known of these compositions is Pyroceram, produced by Corning Glass. These materials have high mechanical strength, heat-shock and erosion resistance, homogeneous structure, and excellent dielectric properties at high temperatures. Although present recommended temperature limitation is 1,830 F., new compositions for use at temperatures to 2,500 F. are under development.

► **"KT" Silicon Carbide**—A practical application of the principle of single-phase, high-density, self-bonded ceramics is illustrated by "KT" silicon carbide, a dense, self-bonded silicon carbide body. This form of silicon carbide lends itself to fabrication of complex shapes, and advances substantially the capability of ceramics to solve severe corrosion and erosion prob-



These RAS Blowers are in sewage treatment aeration service. They are rated 3000 CFM with discharge at 7.5 PSIG. RAS Blowers are suited to chemical processing, pneumatic conveying, metal working applications . . . wherever a blower is used.

Long periods of continuous operation? All round dependability? Oil-free air? Entrained liquid? Varying pressure? Limited installation space?

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RAS Blowers are gas tight, even for hot or light gases. Regardless of varying pressure they deliver a constant volume of oil-free air. Entrained liquids present no mechanical hazards.

Use RAS Blowers to solve your installation problems. Compact, completely enclosed construction not only saves space, it eliminates the need for a base-plate and provides full protection for outdoor installation. Side inlet and discharge connections simplify piping, too.

For maximum dependability–plus more CFM per dollar invested, select the optimum RAS Blower or RGS Gas Pump from 36 sizes, 1500 CFM to 35,000 CFM, with a unit for practically any service from 2 to 12 PSIG.

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ROOTS **DRESSER INDUSTRIES INC.**
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lems. Because of its high relative density (97% of theoretical), "KT" silicon carbide is impermeable and dramatically superior to other commercially available silicon carbide bodies in corrosion resistance and mechanical properties.

Manufacturing process—"KT" silicon carbide, developed in The Carborundum Company laboratories, is formed by conventional ceramic techniques such as cold pressing and extruding. If necessary, machining can be performed in the green state before firing. Parts are fired at high temperatures.

The surface of as-fired "KT" silicon carbide is somewhat rough, owing to crystal formation during firing. Precision finishes are readily obtained by diamond grinding.

The property that sets "KT" silicon carbide apart from other commercially available forms of silicon carbide is the minimum apparent specific gravity of 3.10 gm./cc. This high value, within 3% of the value for a theoretically dense body, is the key to the attainment of the superior physical properties, especially strength, thermal conductivity, and corrosion resistance.

Working temperatures for "KT" silicon carbide range from 3,000-4,000 F., which illustrates the superior oxidation resistance of silicon carbide. High-temperature materials such as graphite and molybdenum oxidize rapidly as low as 1,000 F.

The modulus of rupture and the compressive strength are very high; up to ten times that of other silicon carbide bodies, and three to ten times that of graphite, depending on temperature. The excellent strength at very high temperatures permits design of thin-walled tubes and other practical shapes for use at high temperatures.

Thermal conductivity is exceptionally high, exceeding twice that of stainless steel and equal to that of graphite. The thermal coefficient of expansion is low; an order of magnitude lower than nickel, stainless steel, etc., which permits shrink-fitting.

Wear resistance—Wear and erosion are difficult to predict. Besides external conditions such as environment, relative velocity and temperature; the problem is also influenced by material properties such as hardness, porosity, grain size and nature of the bond.

The outstanding wear-resistance of dense silicon carbide is implied by its hardness, which is exceeded only by diamond and high-density boron carbide and far exceeds the hardness of more-common wear-resistant materials.

Some of the more interesting applications:

- Orifice plates for metering 95% sulphuric acid at 200 C. (under these conditions, no corrosion or erosion has been detected). The advantage of an orifice plate that will maintain its calibration over a long period, even in severe service, is obvious.
- Precision parts for acid service, 24-hr per day, in a 3-8% sulphuric acid solution at a temperature of 50-60 C. During an entire year, "KT" silicon carbide rods wore only 0.003 in. on the diameter. In addition to the severe acid conditions, there was mild abrasion.
- Valve seats and disks for acidic abrasive slurries such as abrasive nickel ore slurry in concentrated sulphuric acid, with temperatures cycling to 475 F.
- Heat exchanger tubes handling 50% nitric acid where both corrosion resistance and high thermal conductivity are required.
- Piping for carrying chlorine at temperatures between 400 C. and 600 C.
- Nozzles in wet cyclone systems. One nozzle has now handled over 50,000 tons of hard taconite ore and is still in service.
- Nozzles for pulp cleaners and wear sleeves for pulp digester. A nozzle has operated for 6,800 hr., handling 17,000 tons of abrasive pulp slurry.
- Wiper blades for conveyor belts. "KT" silicon carbide has been in service for over one year, scraping a mixture of coke and salt. Wiper blades of fused alumina last 3-5 wk. in this application.
- Usage as a thermocouple protection tube. The particular advantages in this application are high strength at high temperatures, very high thermal conductivity, and excellent oxidation and thermal shock resistance.

The properties and applications of just one self-bonded, high-density industrial ceramic have been covered. But the dramatically superior properties of dense silicon carbide, compared with those of other silicon carbide bodies, illustrate the advances that can be expected in corrosion- and wear-resistant ceramics as a result of current research programs.

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Meet the Author

M. F. KIACHIF *is project manager of the High Temperature Materials Project in the R&D Div. of The Carborundum Co. He is responsible for the development and sales of "KT" silicon carbide and boron carbide as well as development and production of boron nitride.*

He received his A.B. and a B.S. in mechanical engineering from Columbia. A member of Tau Beta Pi, he is also a licensed professional engineer in N. Y.

Progress Report...

Streamlined processing—with 2-methyl-1-butanol, commercial

Like almost everything in our modern world, chemical processes can be streamlined, too. In short, you can get faster reactions with fewer side reactions, by-products, and residues.

If your process employs a primary alcohol, you can "streamline" it with CARBIDE's commercial grade of 2-methyl-1-butanol, consisting entirely of five-carbon primary alcohols. Used as an intermediate, this mixture gives quick, complete reactions and highly efficient production. There are no competing side reactions, no by-products, and no un-reacted residues.

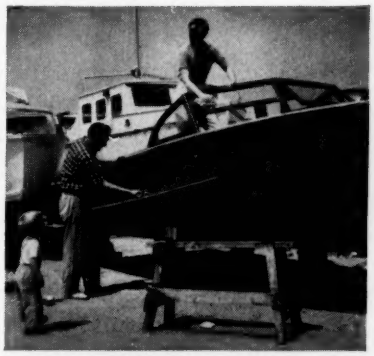
Water-white, liquid 2-methyl-1-butanol is a mixture of the branched chain primary amyl alcohols: 2-methyl-1-butanol and 3-methylbutanol-1 with small amounts of pentanol-1. Typical analysis shows 86% by weight of 2-methyl-1-butanol. Boiling point of the mixture is 130° C. and it sets to glass below −90° C. In water at 20° C., it is 2.2% soluble by weight.

While the primary alcohols in amyl mixtures have similar physical and reaction properties, their pharmacological properties are distinctive. Where isomeric contamination is undesirable, the use of 2-methyl-1-butanol permits preparation of products with controlled flavor, odor, and biological characteristics.

The branched-carbon structure of 2-methyl-1-butanol has advantages where solubility, compatibility, and substantivity are important. Its molecular structure is a major factor in lubricants, helping to provide low-temperature pour-points without sacrifice of body at high temperatures. Branched-chain ester plasticizers are faster-solvating and are compatible in a wide variety of systems. In resins, methyl substitution reduces crystallinity. Additives for oils, greases, paints, and other oleaginous materials are more compatible and more soluble when made from such intermediates. Check the coupon below for a copy of a technical bulletin.

Now molten UCAR butylphenol 4T available in tank cars

UCAR butylphenol 4T is now being shipped in molten form in both insulated tank cars and tank trucks. This relatively new chemical is also supplied in near-white flake form in 50-pound bags. Its molecular weight is 150.21 and specific gravity is 0.9081 at 114/4° C. Freezing point is 97° C., and boiling point, 236°-238° C. at 760 mm. CARBIDE produces UCAR butylphenol 4T to these specifications: *para*-Tertiary-butylphenol—97 wt. % min.; *ortho*-Tertiary-butylphenol—1 wt. % max.; Di-tertiary-butylphenols—2 wt. % max.



UCAR butylphenol 4T is the starting material in the production of oil-soluble phenolic and modified phenolic resins used for varnishes and lacquers. Combined with appropriate drying oils, the resins give light-colored coatings that are rapid-drying, tough, and resistant to light, water, acids, and alkalies.

UCAR butylphenol 4T is also useful as an intermediate in the manufacture of other products of many types. Among these are antioxidants, waterproof starch finishes and adhesives, pour-point depressors and emulsion breakers for petroleum oils, vinyl ether and dimethylol melamine type plastics, tackifiers and vulcanizers for rubber and curing agents for neoprene adhesives, synthetic lubricants, insecticides, and industrial odorants. For prices and a special Technical Information Bulletin, check the coupon.

Sure cure for epoxy resins

CARBIDE's alkylene amines are effective curing agents or hardeners for both liquid and solid types of epoxy resins. Diethylene triamine, triethylene tetramine, dimethylamino propylamine, and diethylamino propylamine are excellent for room-temperature curing of small masses of resin. These amines are especially suitable when used with resins intended for potting or encapsulating electrical components. The alkylene amines are also used as curing agents in laminating resins.

An interesting new booklet on CARBIDE's epoxy curing agents is now available. For your copy, check the coupon.

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- ☐ Bulletin F-8665B (Epoxy Resins)
- ☐ Physical Properties of Synthetic Organic Chemicals — a comprehensive description of the properties and applications of nearly 400 CARBIDE chemicals.

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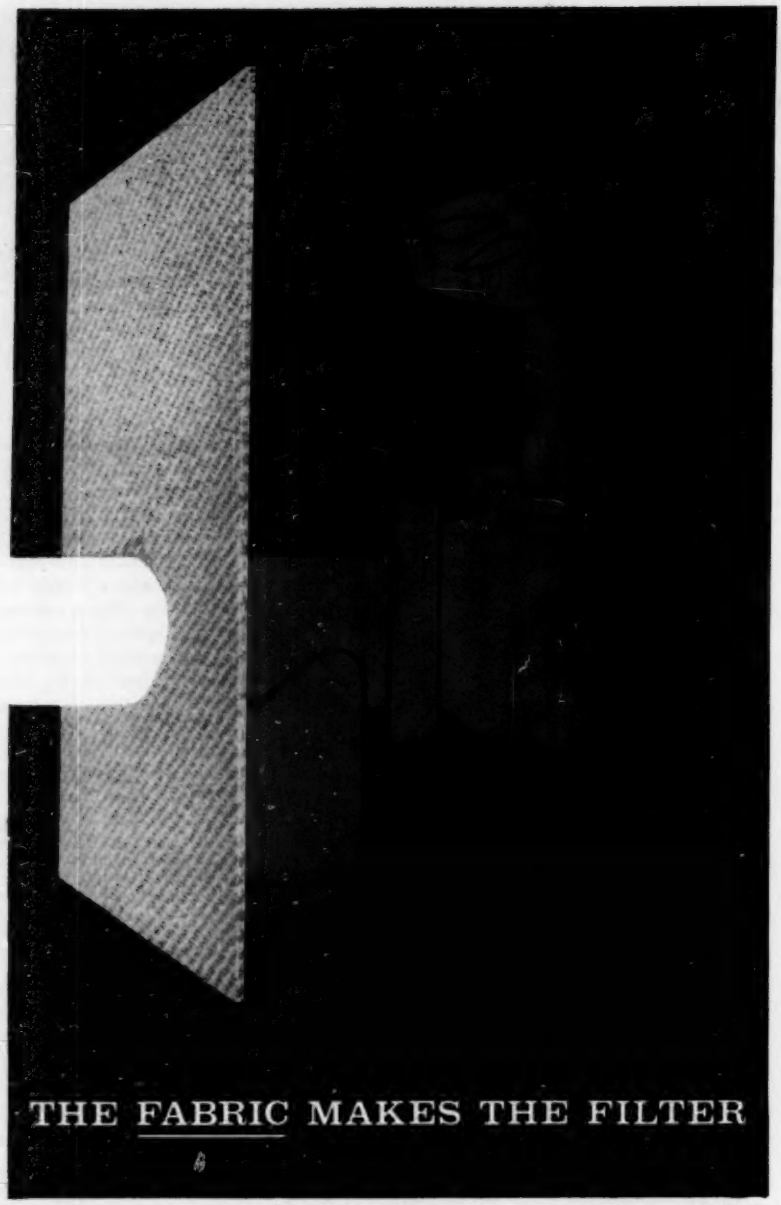

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CPI NEWS BRIEFS . . .

(continued from page 52)

Stearns-Roger Mfg. Co.) Over $25 million will be spent on the project before shaft reaches potash deposit late in 1962.

Continental Oil Co. will build a $1.75-million plant at Hennessey, Okla., under a 50-50 investment scheme with an amalgam of undisclosed firms and individuals in Oklahoma. Facility will process 30 million cu. ft./day of natural gas into propane, butane and other natural gas products.

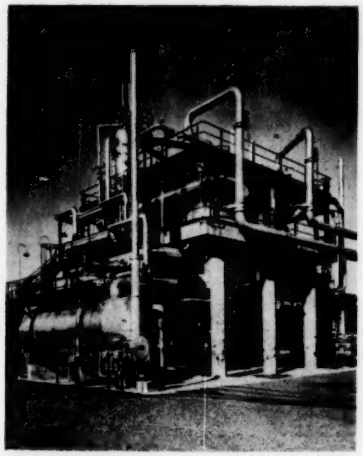
Celanese Corp of America has awarded Brown & Root, Inc., the construction contract for its 20-million-lb./yr. Celcon plant at Bishop, Tex. Due on stream early in 1962, facility will turn out the patented acetal copolymer from trioxane, a formaldehyde derivative. Du Pont's patent-infringement suit over the process is still pending.

Aluminum and Magnesium Inc., a small Sandusky, Ohio, firm, plans to create a subsidiary—Luckey Industries, Inc.—to extract magnesium from 9 million lb. of government-surplus magnesium bombs. Firm has bought from the government (for around $316,000) a former Brush Beryllium magnesium-reduction plant at Luckey, Ohio, to which it will ship the bombs from their present, undisclosed storage location on the West Coast. Company estimates extraction project will take about three years to complete, plans to begin this July.

W. R. Grace & Co. has contracted Foster Wheeler Corp. to build a 60,000-ton/yr. ammonia plant in Big Spring, Tex., at the refinery site of Grace's 53%-owned subsidiary, Cosden Petroleum Corp. Cosden will operate the ammonia facility for Grace's Nitrogen Products Div.

Atlantic Refining Co. has awarded the O. L. Olsen Co., Inc., a $1.5-million contract to construct a refrigerated - absorption gasoline

plant near George West in Live Oak County, Tex. Due on stream late in 1962, facility will process 60 million cu. ft./day of gas into 32,000 gals. of propane; 17,500 gals. of butane; and 7,600 gals. of gasoline.



California Chemical Co.'s Oronite Div. has shipped the first order of packaged maleic anhydride from its new 20-million-lb./yr., multi-million-dollar plant in Richmond, Calif. Constructed by Badger Mfg. Co. and licensed from Reichhold Chemicals, Inc., the installation makes both molten and briquetted maleic anhydride from benzene.

American Oil Co.'s refinery at Texas City, Tex., now has a 201-ft.-high butane splitter—painted bright orange. Tower is one of five being raised by The Fluor Corp., Ltd., to complete a 14,600-bbl./day alkylation unit. Also under construction at the site are a 47,600-bbl./day catalytic cracker and a 150,000-bbl./day pipe still.

Kaiser Aluminum & Chemical Corp. displays significant confidence in rising aluminum demand by reopening three potlines: one at Chalmette, La., with 27,500 tons/yr. of primary-aluminum capacity; another at Mead, Wash., with 22,000 tons; the third at Ravenswood, W. Va., with 36,250 tons.

Ultra Chemical Works, Inc., a wholly owned subsidiary of Witco Chemical Co., Inc., has placed a

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accurate measurement of liquids plus time and labor-saving features... more consistent product uniformity... more complete data for process control, inventory and cost accounting. You can measure liquids under pressure to avoid loss of volatile products... measure cold, or hot, corrosive liquids... and, heavy liquids, even molten sulphur.

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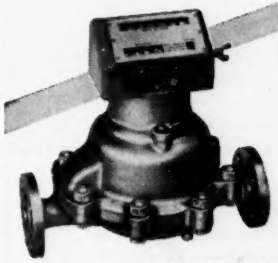

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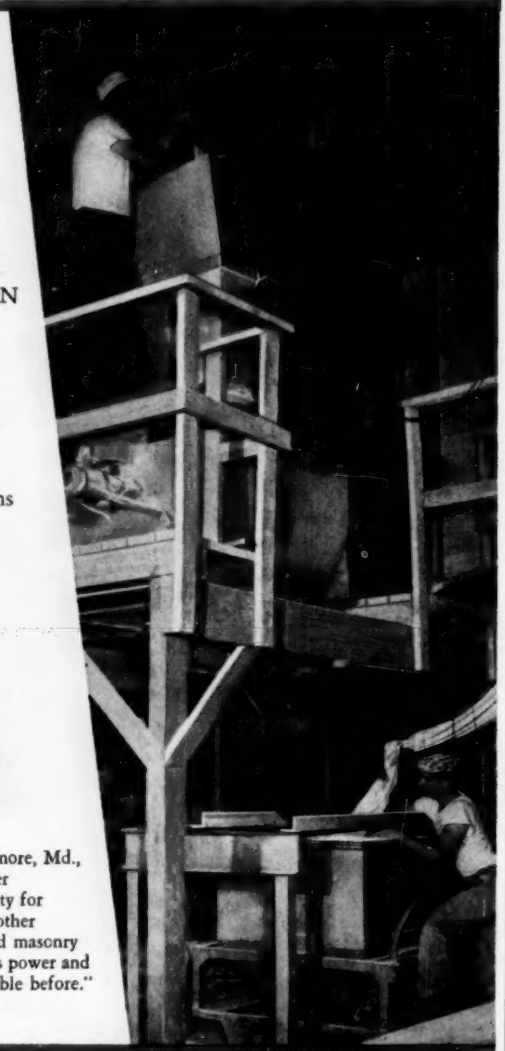

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$1.6-million synthetic-detergent plant on stream at Chicago. Firm's existing capacity (at Paterson, N. J., and Los Angeles) is boosted 60% by the new 15,000-ton/yr. installation. Initial product at Chicago is dodecyl benzene sulfonate.

Atlantic Refining Co. has awarded Pona Engineers the construction contract for a 35-ton/day sulfur plant adjoining its refinery at Port Arthur, Tex. To cost $250,000, facility will feed on refinery's hydrogen sulfide waste gas.

Armour Agricultural Chemical Co. has broken ground at Cherokee, Ala., for a multimillion-dollar nitrogen-products complex. When completed early in 1962, the six-plant project will have daily capacity for 360 tons of ammonia, 50 tons of urea, 250 tons of nitrogen solutions, 300 tons of nitric acid, 250 tons of ammonium nitrate, and 500 tons of ammonium phosphate. Construction is being financed by a $25-million bond issue floated by the town of Cherokee; completed facilities will be leased by the town to Armour.

Transwestern Pipeline Co. has dedicated its $189-million, Texas-to-California gas transmission system at Roswell, New Mexico. Automated, the 1,809-mile pipeline is operated by one man.

Du Pont will build a $250,000 dyeing and textile-finishing laboratory at Charlotte, N. C. Construction of the 9,000-sq. ft. center will begin shortly, is due to be completed by the fall.

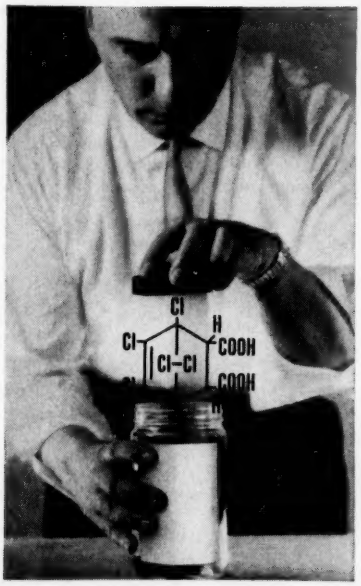
Offices

General Aniline & Film Corp.'s Chemical Group announces relocation of its Chicago branch office to Melrose Park, Ill. New 35,000-sq. ft. building has office, laboratory and warehouse space.

Mobil Chemical Co., a division of Socony Mobil Oil Co., Inc., has

BRIEFS

HET® (chlorendic) acid hypophosphites, Ca and Na organophosphites



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The unique dibasic acid whose formula is shown above presents a number of convenient ways for putting chemically stable chlorine into your product.

This is HET acid. It's 54.7% stable chlorine by weight. It's 99.5% pure. It is white, anhydrous, and crystalline.

It is, above all, highly reactive, undergoing a series of reactions quite similar to those of phthalic anhydride.

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Metal salts. Driers for paints, varnishes, inks, and stabilizers for vinyls. Soap components for greases. Fungicides, herbicides, insecticides.

Imides. Waxes and greases. Agricultural chemicals. Fungicides.

Esters. Plasticizers which impart fire retardance to cellulose acetate, cellulose nitrate, PVC, PVA, GR-S, and other plastics and rubbers.

Resins—glycol, oil modified, and unsaturated thermosetting polyesters.

Bulletin 40-A, offered in the coupon, discusses these and other uses in more detail.

HIGH PURITY HYPOPHOSPHITES

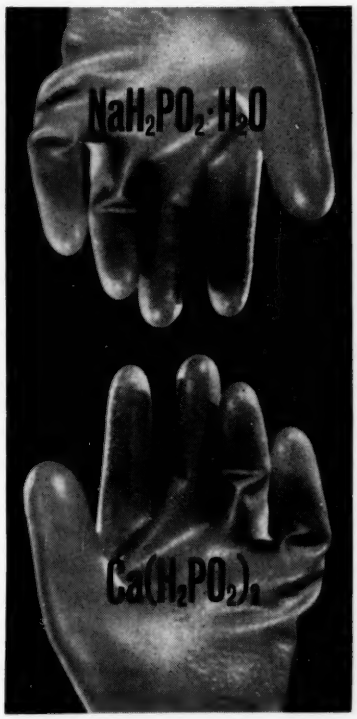
Our National Formulary grades of sodium and calcium hypophosphites not only meet the N.F. tests, but also, typically, exceed the requirements.

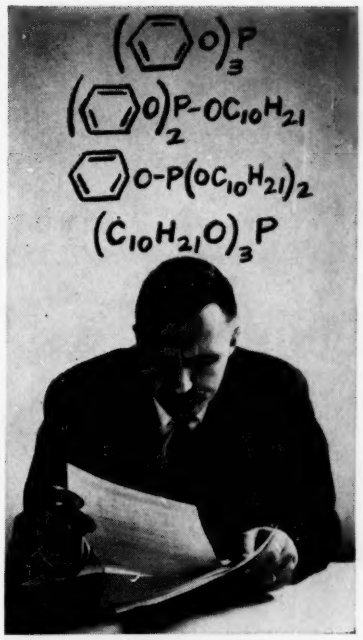
Take a look at the *typical analysis* of N.F. sodium hypophosphite. Assay as $NaH_2PO_2 \cdot H_2O$ is equivalent to 102%; alkalinity is about 0.7 ml 1 N HCl/gm; arsenic is 5 ppm. The product is supplied as free-flowing, white, odorless crystals.

As for N.F. grade calcium hypochlorite, it also more than meets National Formulary requirements. Its assay as $Ca(H_2PO_2)_2$ runs typically at 99%; acidity is 0.3 ml 0.1 N NaOH/gm; arsenic is 5 ppm.

For other uses, particularly in electroless nickel plating, we have a commercial grade of sodium hypophosphite. Its assay as NaH_2PO_4 runs typically at 85%. It is supplied as free-flowing, white, odorless crystals.

For technical data sheets, on any of these compounds, check the appropriate box and mail the coupon.





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In case you are not familiar with these compounds, they read like this: triphenyl phosphite, diphenyldecyl phosphite, phenyldidecyl phosphite, and tridecyl phosphite.

The organophosphites are versatile intermediates which can be used to build other organophosphorus compounds. They are currently being used as components in stabilizer systems for vinyls and other polymers.

The exceptionally high quality of these products, particularly their color and clarity, recommends their consideration for your evaluation. Take for instance the low free phenol of our triphenyl phosphite and the clear, almost water-white appearance of all four. For more details on these products, including specifications, physical and chemical properties, and typical reactions, as well as an extensive bibliography, check the coupon. This data file includes technical data sheets and a special bulletin on Hooker organophosphites.

If you find you may have a use for some of the more exotic forms, you'll find us prepared to manufacture them as the industry need arises.

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- ☐ Organophosphites, Data File.
- ☐ Sodium Hypophosphite, Commercial, Data Sheet.
- ☐ Sodium Hypophosphite, N.F., Data Sheet.
- ☐ Calcium Hypophosphite, N.F., Data Sheet.

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CPI NEWS BRIEFS . . .

completed a 24,000-sq. ft. office building at Beaumont, Tex. Described as the "nerve center" of the firm's Southwest operations, the aluminum-and-glass structure is adjacent to Mobil's almost completed 380-million-lb./yr. ethylene plant.

Companies

Atlas Chemical Industries, Inc., is the new name of Atlas Powder Co., Wilmington, Del. Simultaneously with the name change, Atlas split its stock four for one and acquired The Stuart Co., a pharmaceuticals firm headquartered in Pasadena, Calif.

Southern Oxygen Co., Bladensburg, Md., has executed an abrupt about-face by announcing its merger with **Air Products, Inc.,** of Allentown, Pa. Less than a fortnight earlier, Southern Oxygen and Spencer Chemical Co. had announced their intention to join forces. Current plans appear somewhat more solid, although stockholder approval must still be granted. Air Products would operate Southern Oxygen as a division, shareholders of the latter firm exchanging three of their shares for one of Air Products'.

International

Great Britain: British Hydrocarbon Chemicals Ltd. has released further details on the almost inextricably complicated, multifirm, $28-million chemicals complex planned for southern Wales at Baglan Bay, near Port Talbot. Like BHC's present works at Grangemouth, Scotland, the first Baglan Bay units will make olefins, ethylene, propylene and butadiene. Due on stream by the end of 1962, facility will feed on a light distillate from British Petroleum Chemicals, Ltd.'s refinery at Llandarcy, three miles away. Latter firm, which co-

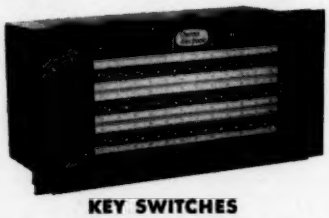
NEW Thermocouple Selector Switches

For fast, accurate indication of temperature from a number of thermocouples—to average readings from several measuring points—or to switch a thermocouple from one instrument to another—choose a new compact Thermo Electric Selector Switch.

These switches are compatible with any thermocouple or resistance thermometer, and any measuring instrument. Steel cases are dust and moisture proof, and are easily mounted on panel, rack, wall, or table.

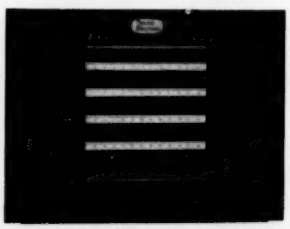
ROTARY SWITCHES

Capacities—OFF to 6, 12 or 24 measuring points. Available with binding post terminals or bunched leads for soldered connections.



KEY SWITCHES

Accommodate 1 to 144 sensing elements—locking or non-locking construction. Choose from several different cabinets.



PUSH BUTTON SWITCHES

OFF to 72 points—interlocking construction so that one switch remains "on" until another is actuated.

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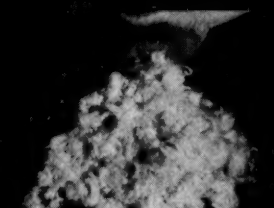

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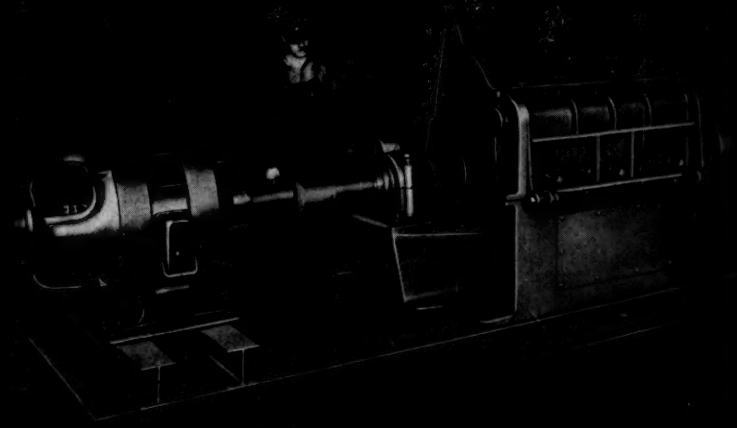
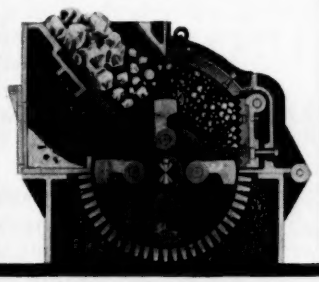


Sectional view of NF and GA type hammer mills, two of many Williams builds. Whether your operation involves grinding, crushing or shredding, Williams can furnish a mill to meet your exact requirements.



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Whether the material is mineral, chemical, animal or vegetable, Williams has a type and size of hammer mill to reduce it from original state to finished size in a single operation!

One Williams mill can do the work of two or more machines—SAVE UP TO 50% ON PRODUCTION COST in labor, power and upkeep—REDUCE ORIGINAL INVESTMENT AS MUCH AS 75% in primary or secondary units, drives, conveyors, foundations and other equipment.

Superior engineering and stronger construction also pay extra dividends in years of added service, less downtime, fewer replacement parts. Welded, massively reinforced steel plate frames—manganese steel liners and breaker plates—oversize shafts and discs—oversize, sealed, self-aligning bearings—all give optimum resistance to shock and abrasion. Quick, easy accessibility to interiors reduces maintenance time and trouble. Many more exclusives, unavailable in other equipment, promise ultimate economy, increased output and product improvement.

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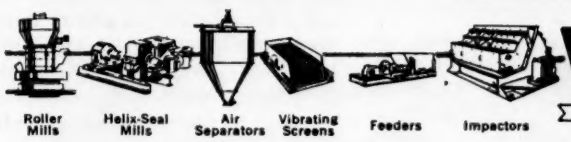

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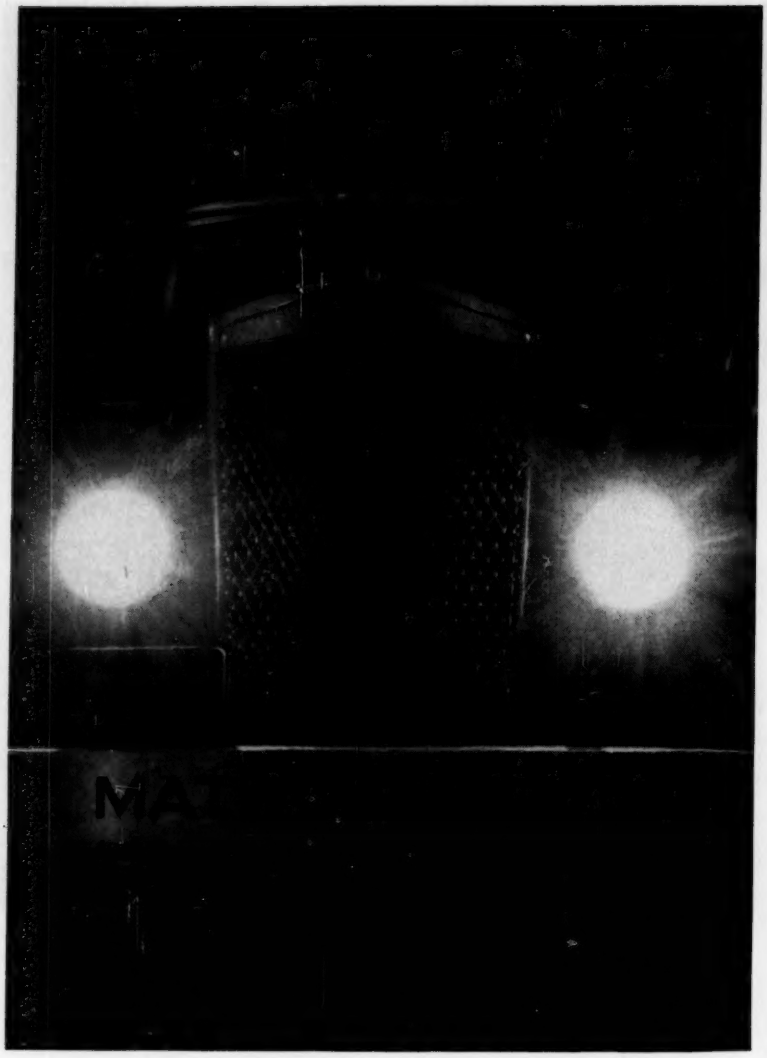

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656

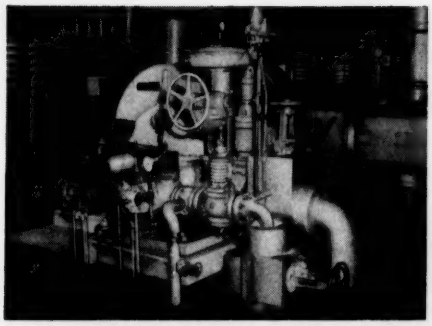
owns BHC with Distillers Co. Ltd., will turn some ethylene into ethylene dichloride; which, in turn, will be converted to polyvinyl chloride at an existing plant in nearby Barry, Wales, by British Geon Ltd. (owned 55% by Distillers Co., 45% by B. F. Goodrich). Remaining ethylene will go into styrene monomer, to be manufactured at the Baglan Bay site in a plant under construction by Forth Chemicals, Ltd., jointly owned by BHC and Monsanto Chemical Ltd. Polystyrene will be made at the same site in a unit run by two other Distillers Co. associates, Distrene Ltd. and B. X. Plastics Ltd. No capacity figures have been released.

Japan: Mitsubishi Oil Co., half-owned by Tidewater Oil Co., has placed its 40,000-bbl./day refinery on stream at Mizushima, Honshu. Installation's cost has been pegged at more than $40 million.

Vietnam plans a chemicals center at An-Hoa, 23 mi. southwest of the port of Tourane. Selected for its proximity to the Nong-Son coal mines, site will hold a 55,000-ton/yr. urea-fertilizer plant, an 8,000-ton/yr. calcium cyanamide factory, and eventually a bamboo-fed facility for making pulp and rayon. Proposed coal-fed power plant would generate 16,000 kw.

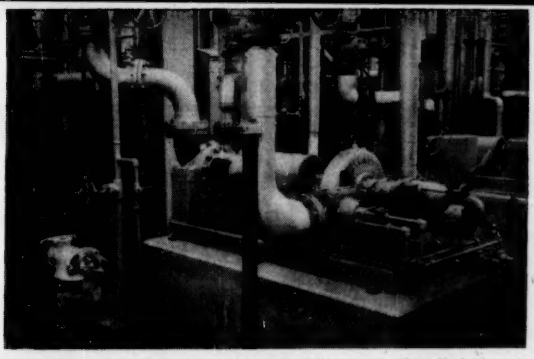
India has awarded a multimillion-dollar contract to a consortium of five West German, Australian and Indian firms for design and construction of a $40-million briquetting and carbonizing plant at Neyveli, a small village over large lignite deposits in southern India. About 714,000 tons of raw briquettes are scheduled for annual production by 1964.

U.S.S.R. and **Yugoslavia** have signed a five-year, lopsided trade agreement, under the terms of which the Soviets will export to the Yugoslavs heavy equipment for a $95-million industrial building project, and undisclosed millions in raw-material chemicals; in return, Yugoslavia will send sixteen 25,000-ton tankers, nine

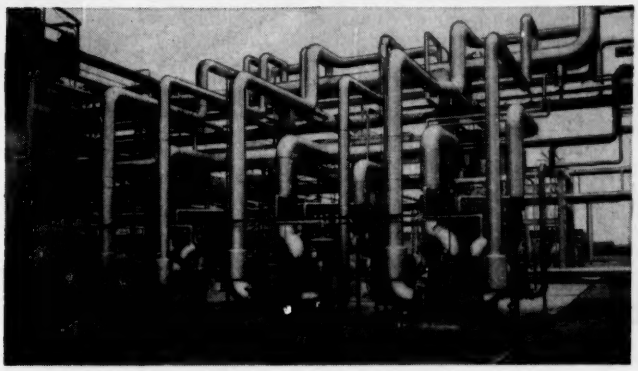


600-hp Elliott turbine driving a compressor which supplies compressed air for process.

(Right) Elliott steam turbines power many reflux pumps throughout the refinery. Shown here are three, driving gasoline column bottoms pumps in the crude unit.



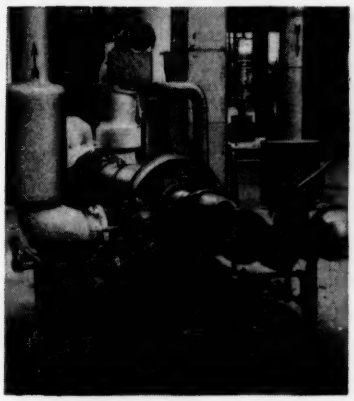
The YR turbine shown above drives an oil pump in the alkylation plant.

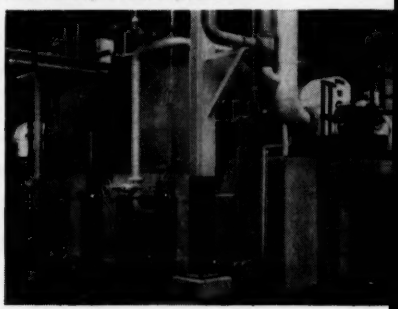


The turbine-driven condensate pump shown below charges foul condensate to stripper column.

Below are forced-draft fans driven by Elliott turbine-gear units in one of the refinery's boiler plants.

The unit on the left above is a condensate pump, and the one on the right is a seal oil and flushing oil pump. Both are driven by Elliott turbines.





FROM TURBINE HEADQUARTERS

In one refinery, 85 Elliott turbines driving pumps, compressors, fans prove Elliott versatility

Ranging in size from 5 to 935 horsepower, these Elliott YR single stage turbines are installed in a giant East Coast Refinery. The units were selected from a modern, field-proven line of mechanical drive turbines rated up to 50,000 horsepower.

Installations like this together with experience of more than 50 years in turbine design, manufacture and application are among the reasons why Elliott is truly "Turbine Headquarters." Write for descriptive bulletin H22-D. H1-2

day-in/day-out

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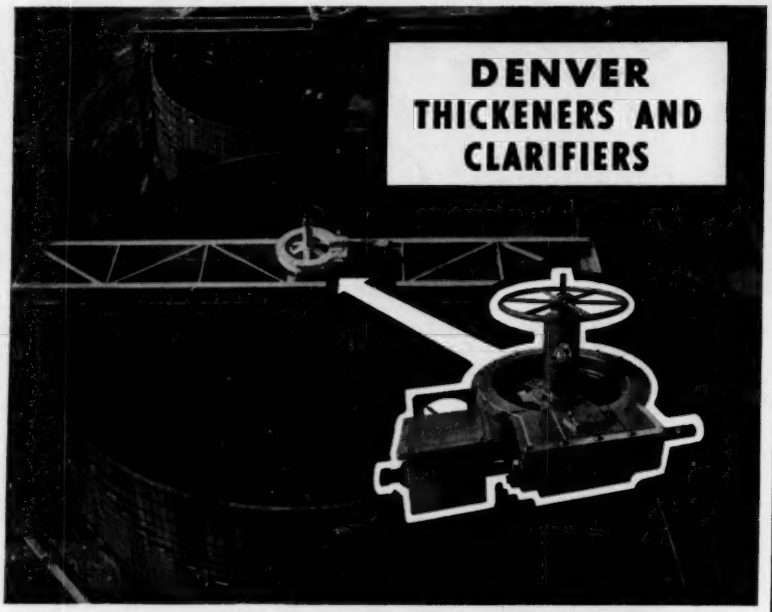

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FULLY ENCLOSED MECHANISM with simple, rugged gear and drive mechanism—in sizes through 72" for thickeners to 150' dia.

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LABORATORY TESTING SERVICE supplies reliable data on **Settling Rates, Final Density, Effect of Flocculating Agents, Thickener Unit Area, Overflow Clarity.**

Write for Bulletin No. T5-B6.

DENVER Adjustable Stroke DIAPHRAGM PUMPS

...for handling and metering thickened solids

Stroke adjustable while pump is operating. Low head design...anti-friction bearing construction. Specially-shaped nylon reinforced rubber diaphragm gives long life. Sizes 1" to 10", simplex and duplex. Capacity to 1000 gpm. Rubber covered or stainless steel construction available. Write for Bulletin No. P8-B12.

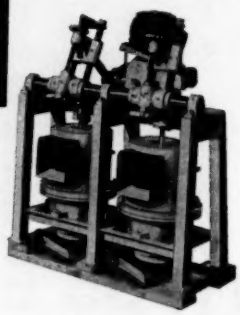

Table at right shows a few of the sizes available:

Pump Size and Type	Cap. Water GPM Min. Stroke	Cap. Water GPM Max. Stroke	Motor HP
2" Simplex	11	25	1/2
4" Simplex	25	70	1
6" Simplex	90	180	3
8" Simplex	165	330	5

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10,000-ton freighters, and miscellaneous machines and chemicals to the Soviet Union.

Rumania: Petrocarbon Developments Ltd. will supply Rumania with a $2.24-million polystyrene plant, due on stream by the end of 1962. Contract represents the first major Rumanian order for a plastics facility since the Anglo-Rumanian trade agreement was signed, although Petrocarbon engineered a similar polystyrene unit for Poland last year.

West Germany: Esso A.G., Hamburg, has begun preliminary work at the site of its $37- to 50-million refinery near Ingolstadt. Esso A.G.'s sister company, Esso Research & Engineering Co. in Linden, N. J., is handling design and engineering for the 40,000-bbl./day facility, due on stream at the end of 1964.

Japan: Teikoku Rayon has been licensed by Snia Viscosa in Milan to make nylon via the Italian firm's newly developed caprolactam-from-toluene route. Previously licensed were Courtaulds, Ltd., and Allied Chemical Corp.

Switzerland's first petroleum refinery is under construction at Collombey, by Raffinerie du Rhone S.A. Due on stream late in 1962, facility will process 2 million tons/yr. of crude into 1.4 million tons diesel and fuel oils, 400,000 tons benzene, and lesser tonnages of gasoline and residual oils. Crude will be pipelined from Genoa, Italy, by the Italian state monopoly ENI.

Great Britain's first butyl rubber plant, a $12.5-million unit with annual capacity for 25,000 tons of the elastomer, will be constructed for Esso Petroleum Co. Ltd. by Foster Wheeler Ltd. Ethylene-butadiene facilities at the site—Esso's Fawley refinery near Southhampton, Hampshire — are already under construction. Work on the butyl installation will begin shortly. Butyl process involves copolymerization of isobutylene and isoprene over an aluminum chloride catalyst.

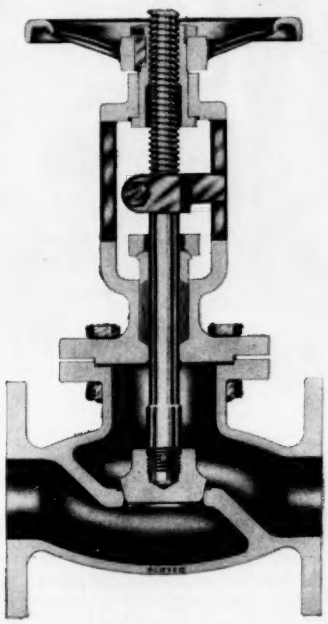

Fig. 311-B

Do you know the advantages of the new Aloyco Globe Valve design?

The design of 150 lb. globe valves of sizes 2" and larger features a non-rotating stem, non-rising handwheel with disc assembly pinned to the stem. This is accomplished by rotating the handwheel and yoke bushing assembly and preventing stem rotating by adding a stem key which fits into the bonnet yoke. The major advantages of the new design result in:

- No spiral wear pattern on stem from hardened packing or hard deposit in stuffing box.
- Rapid visual check of throttling control by observing location of stem stop.
- No galling of back seat because of rotating stem.
- No galling between seat and disc.
- Stronger disc to stem connection.
- No spinning of disc.
- Less corrosion attack because of elimination of cavity between stem and disc.

These new design advantages are available in stainless steel and corrosion resistant alloys in sizes 2" and up. For full information write for Bulletin #7, Alloy Steel Products Company, Inc., 1301 West Elizabeth Avenue, Linden, New Jersey. O.11

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Fuller Portable Airveyor® Transfer Units convey pelletized or granulated plastics and similar materials with high efficiency . . . provide a self contained loading and unloading unit for greater flexibility.

FULLER low cost transfer unit expedites handling of granular chemicals and plastics

Get high conveying capacity—when and where you want it—without the expense of duplicating equipment. Fuller Portable Airveyor® Transfer Units provide flexible, lower-cost handling to and from cars, trucks, storage bins and silos of every type. Hook-ups are quicker, too, because these Fuller units use pipes, hoses and nozzles of minimum size to deliver maximum capacity. Units combine clean-cut appearance with compactness and stamina never before available in portable equipment. Made in three sizes, the units are rated to handle pellets from 4 to 20 tons per hour for conveying distance of 30 feet on the suction side and 100 feet on the pressure side.

For full details, write for Bulletin A-23.

See Chemical Engineering Catalog for further details and specifications.

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Convention Calendar

June

4-7. The University of Wisconsin, 3rd Annual National Industrial Pharmaceutical Research Conference, King's Gateway, Land O'Lakes, Wis.

4-8. American Nuclear Society, Annual Meeting, Penn-Sheraton Hotel, Pittsburgh, Pa.

5-9. Society of the Plastics Industry, National Plastics Exposition and Conference, New York Coliseum, and Commodore Hotel, New York, N. Y.

5-16. Johns Hopkins University, Operations Research and Systems Engineering Course, Baltimore, Md.

6-8. Instrument Society of America, Summer Instrument-Automation Conference, Royal York Hotel and Queen Elizabeth Hall, Toronto, Canada.

7-9. Canadian Pulp and Paper Assn., 1961 Summer Meeting, Saranac Inn, Saranac, N. Y.

8-10. Manufacturing Chemists' Assn., 89th Annual Meeting, The Greenbrier, White Sulphur Springs, W. Va.

9-17. 1961 ACHEMA Chemical Engineering Congress and Exposition, Frankfurt am Main, Germany.

11-14. American Society of Mechanical Engineers, Summer Annual Meeting, Statler Hilton Hotel, Los Angeles, Calif.

11-15. Air Pollution Control Assn., 54th Annual Meeting, Hotel Commodore, New York, N. Y.

11-23. The Pennsylvania State University, Engineering Seminar on Solid State Mechanics, University Park, Pa.

12-16. Air Pollution Control Assn., Annual Meeting, Hotel Commodore, New York, N. Y.

13-16. Instrument Society of America and Michigan State University, 3rd International Symposium on Gas Chromatography, Kellogg Center, East Lansing, Mich.

14-16. American Society of Mechanical Engineers, Applied Mechanics Conference, Illinois Institute of Technology, Chicago, Ill.

16-25. Europlastica, International Plastics Exhibition, Ghent, Belgium.

19-21. University of Southern California, Heat Transfer and Fluid Mechanics Institute, Los Angeles, Calif.

19-23. Massachusetts Institute of Technology, Technology of Reinforced Plastics Course, Cambridge, Mass.

19-30. The University of Michigan, Engineering Summer Conference on Systems Engineering, Ann Arbor, Mich.

20-26. European Federation of Chemical Engineering, Third Congress, London, England.

21-1. Interplas 61. Sixth International Plastics Exhibition and Convention, Olympia, London, England.

21-23. American Assn. of Cost Engineers, Annual Meeting, Somerset Hotel, Boston, Mass.

22-25. Society of Women Engineers, National Convention, Statler-Hilton Hotel, Boston, Mass.

23-25. Compressed Gas Assn., Inc., 48th Annual Meeting, Waldorf-Astoria Hotel, New York, N. Y.

25-30. American Society for Testing Materials, Annual Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

26-30. American Society for Engineering Education, Annual Meeting, University of Kentucky, Lexington, Ky.

26-7. Massachusetts Institute of Technology, Summer Program on Dynamics and Control of Chemical Engineering Processes, Cambridge, Mass.

28-30. American Institute of Chemical Engineers, Instrument Society of America, American Institute of Electrical Engineers, American Society of Mechanical Engineers, Institute of Radio Engineers, Joint Automatic Control Conference, University of Colorado, Boulder, Colo.

July

3-7. Gordon Research Conference, Polymers, Colby Junior College, New London, N. H.

4-7. National Society of Professional Engineers, Annual Meeting, Olympic Hotel, Seattle, Wash.

Later

September 3-8. American Chemical Society, National Meeting, Chicago, Ill.

October 11-12. CHEMICAL ENGINEERING and Armour Research Foundation, Conference on the New Trends in Chemistry, Sheraton Towers Hotel, Chicago, Ill.

November 27-December 1. 28th Exposition of the Chemical Industries, New York Coliseum, New York, N. Y.

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Chromalox Electric Circulation Heaters are complete packaged, highly efficient units used for drying, heating, preheating and superheating materials, particularly those easily damaged by overheating. Temperatures to 1200° F. and above are easily, quickly reached and accurately maintained. Heaters can be installed anywhere with minimum labor and time, and will give long dependable service with minimum attention. Many standard models in stock for immediate shipment. Other models built to meet special corrosive conditions.

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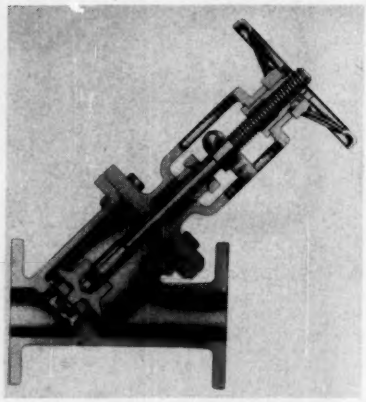
7514 THOMAS BLVD., PITTSBURGH 8, PA.

NEW EQUIPMENT . . .
(Continued from page 62)

new feeder is provided with an insertable metering orifice, drilled to meet volume-viscosity requirements of various specified fluids.

Unit fits standard 2-in. drum bung, can be changed from one drum to another without tools. It can also be adapted for a solenoid timer or for vacuum or pressure service. — **Norcross Companies, Bloomfield, N. J.** 62D



Globe angle, "Y" valve

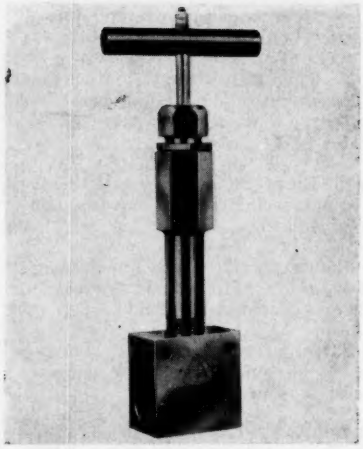
Nonrotating stem and fixed disk prolong operating life.

A newly designed valve is said to have longer life and improved throttling control over conventional types because of its nonrotating stem and fixed disk.

The unit is said to eliminate stem vibration and chatter, prevent galling between the stem foot and the disk, and preserve a tight seal at the packing gland because the stem does not rotate in the packing.

Visual measure of the degree of throttling is provided by a stem key that moves in relation to the valve yoke, making it possible to calibrate the valve position.

Globe, angle and "Y" valves are available in 2-in. and larger sizes in a 150-lb. type. For corrosion-resistant service, valve cames in stainless steel, Monel, nickel and Hastelloy B and C, with renewable disks of Teflon or other resistant materials.—**Alloy Steel Products Co., Linden, N. J.** 134A

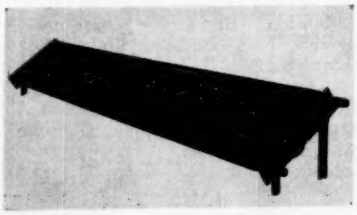


High-temperature valve

Stainless steel tubing valve is good to 1,000 F., pressures to 30,000 psi.

An elongated stuffing box removes the packing from the hot zone of the valve body itself in a tubing valve designed for either gas or liquid service at high temperatures and pressures.

Fluid temperatures above the rated 1,000 F. are tolerated if the valve body is well insulated and the packing area well ventilated. Valve stem is designed in two pieces so it does not rotate against the seat. Two-piece stem is said to eliminate galling or scoring of either the seat or the stem.—**Autoclave Engineers, Inc., Erie, Pa.** 134B



Tank heater

Lightweight unit has finned tubes to give high heating capacity.

Helical aluminum fins locked tight on steel pipe give this six-pass tank heater a high heating capacity per foot of pipe length, and help to make it light enough

Master control station governs synchronized operation of entire liquid polish packaging line. Operator can stop, start, speed up or slow down production at will — avoiding jams or bottlenecks
The key components of the Syncro-Range Drive —
Adjustable Frequency Power Supply
. . . And Standard or Syncro-Spede Motors!

LOUIS ALLIS SYNCRO-RANGE DRIVES automate liquid polish lines

Johnson's Wax, renowned wax and polish producer, uses Syncro-Range Drives for exact control of process lines

Controlling the speed of the precise, mass-production lines for their new, highly successful liquid shoe polish was the task Louis Allis engineers had to solve for Johnson's Wax.

The problem was to time the flow of plastic bottles, liquid polish, wool daubers, and caps into the packaging lines at precisely equal rates. Flow rate must be adjustable so the lines can be slowed down or speeded up. And the entire packaging operation must be controllable from a single master control. The Louis Allis Syncro-Range Drive solved the problem.

Syncro-Range Drive provides synchronized speed of any number of motors from a single control. It is a "packaged system" comprising an adjustable frequency power supply operating on 3 phase, 60 cycle power input . . . a group of Syncro-Spede® synchronous motors which maintain exact synchronism regardless of varying load . . . and a control which permits the speed of the entire group of motors to be simply adjusted without losing synchronization. On applications for which exact synchronism is not required, standard squirrel cage motors can be supplied.

You can readily see the advantages of the Syncro-Range Drive in systems or processes which require synchronized movement: multiple conveyors which feed consecutively; transfer lines; process lines; assembly lines requiring coordinated arrival of components; printing where one press feeds another; synthetic fibre spinning, drawing, or twisting; metal runout tables; and other similar machines which require the application of power at a number of points on the machine.

The Syncro-Range Drive is available with a choice of drive sizes to efficiently control from 2 to 200 motors. Control features are available to provide speed regulation accurate to 0.1% with 0% relative speed difference between motors! A trained Louis Allis motor application engineer is available to help. You can reach him at your local Louis Allis District Office, or by writing to The Louis Allis Company, 447 East Stewart Street, Milwaukee 1, Wisconsin.

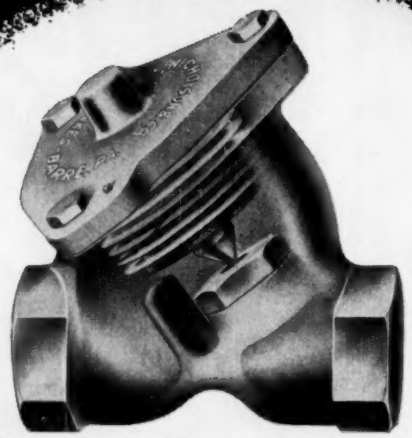
A10-232

LOUIS ALLIS

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

A NEW DEVELOPMENT

FOR STEAM-SAVING EFFICIENCY



Nicholson Thermostatic Steam Trap Model N-150

- ALL STEEL CONSTRUCTION
- JUST ONE WORKING PART
- RUGGED MONEL BELLOWS
- NEW BAFFLE* . . . deflects steam upward and away from the orifice to surround the bellows
- FREEZE PROOF WHEN INSTALLED VERTICALLY
- CAN BE TESTED AND INSPECTED WITHOUT BREAKING PIPE CONNECTIONS
- COMPACT, LIGHTWEIGHT, EASY TO INSTALL
- FOR TRACER LINES also Plating Tanks Platen Presses • Unit Heaters • Sterilizers and various types of Cooking and Laundry Equipment. N-150 Traps can also be used as air vents for Receivers, Water Heaters, Mechanical Traps, etc.

Our 80th Year

- W. H. NICHOLSON AND CO.
12 Oregon St., Wilkes-Barre, Pa.

* Patent applied for

for two men to handle in the field together.

Heater will fit through a standard 20-in. manhole, can be installed in new or existing tanks, singly or in banks. Four legs hold the heater in a sloping position about 6 in. above the tank bottom. Fins, in a vertical position, are washed by the circulating action of the heated tank products.

Weighing 170 lb., the unit provides 223 sq. ft. of heating surface. One-pipe construction with just a single weld avoids the need for stress relieving of the heater. **—Griscom-Russell Co., Massillon, Ohio.** **134C**

Stationary mixer

Centrally positioned lifting screw is the only moving internal part.

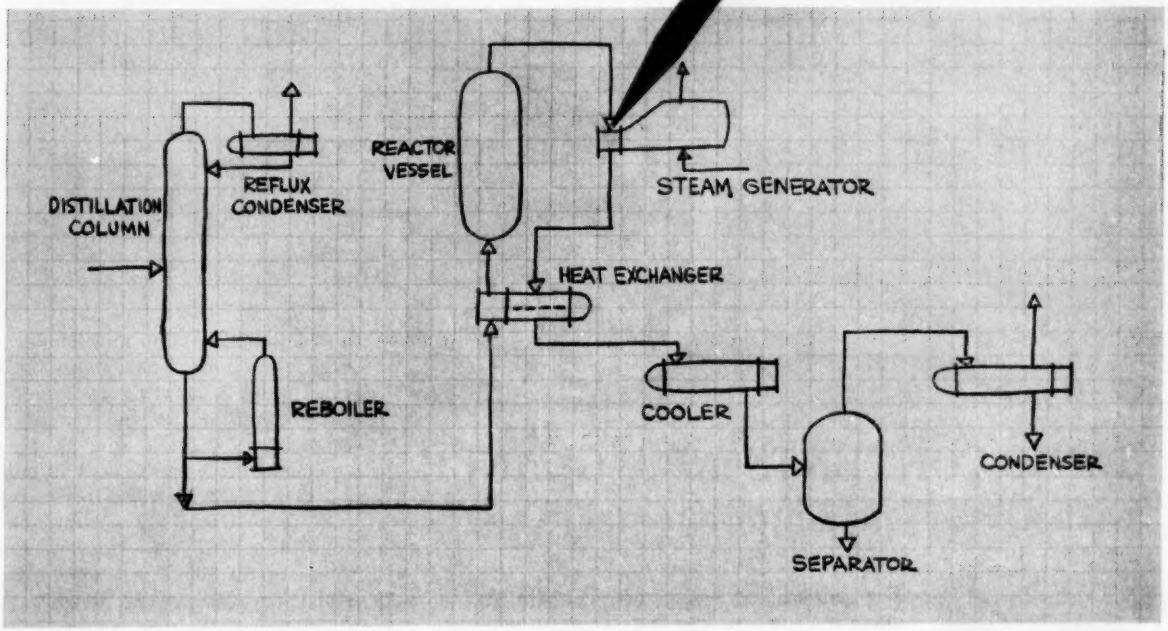
From 2 to 185 cu. ft. of material is continuously lifted to the top of the cone in a series of stationary mixers that feature only one moving part—the screw. Blended material flows by gravity to the bottom of the cone where the lifting cycle is repeated.

Called Tur-Blend, the unit mounts in a minimum floor space because no special foundation or guard rails are required. The batch is charged at the top; blended ma-

when you plan your process...

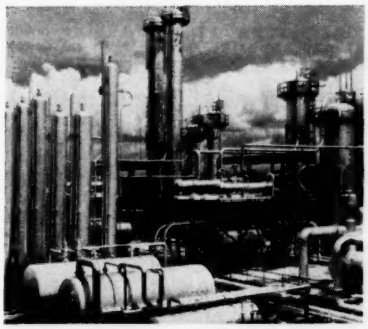
plan on A. O. Smith

for custom-built pressure vessels, heat exchangers and related products



Plan on A. O. Smith for your process equipment—and plan with confidence. A. O. Smith has the facilities and know-how to custom-tailor process equipment to your exact specifications. A world-recognized leader in the process equipment field, A. O. Smith can provide quality-built components to satisfy any process requirement.

However, building modern process equipment is only part of the A. O. Smith plan. Also available to you is the industry's most respected staff of research scientists, technicians and engineers who will help you analyze your operating conditions and make suitable recommendations backed by long experience.



Many modern process plants have a complete range of A. O. Smith custom-built equipment, such as: heat exchangers • reboilers • evaporators • condensers • coolers • columns • hydraulic cylinders • air storage vessels • reactors • autoclaves • tanks.

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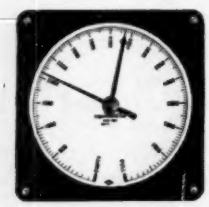
TANK CONTENTS AT-A-GLANCE with Dial-Type Liquidometer Gauges



For added assurance of accurate liquid quantity record keeping, specify easy-to-read Liquidometer gauges. Positive dial-and-pointer type indicators help to prevent erroneous readings . . . speed record keeping by showing tank contents at-a-glance.

Liquidometer gauges are available to measure and indicate virtually any liquid – at the tank site or remotely. Also available: integral or separate liquid level switches for automatic level warning or control. Float, hydrostatic, electric, or electronic operation can be supplied to meet your specific needs.

Let Liquidometer's forty years of experience in liquid level gauging and control work for you. Write for latest literature.

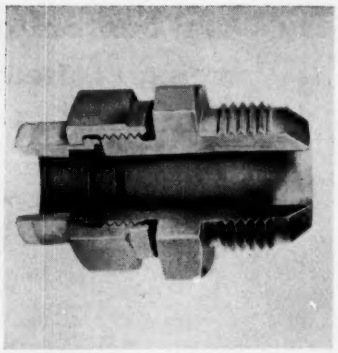
LIQUIDOMETER INSTRUMENTS

THE LIQUIDOMETER CORP.

Dept. Q, LONG ISLAND CITY 1, NEW YORK

terial is removed through the bottom outlet.

Vessel and central tube (in which screw moves) may be jacketed for heating or cooling, or may be enclosed for vacuum drying of free-flowing materials. — **Goslin-Birmingham Mfg. Co., Birmingham, Ala.** **136A**



Tubing coupling

High-pressure, high-temperature unit seals tighter with pressure.

Vibration, shock, pressure overloads, pulsing action and temperature variations won't cause this rigid tubing coupling to lose its seal, according to the manufacturer.

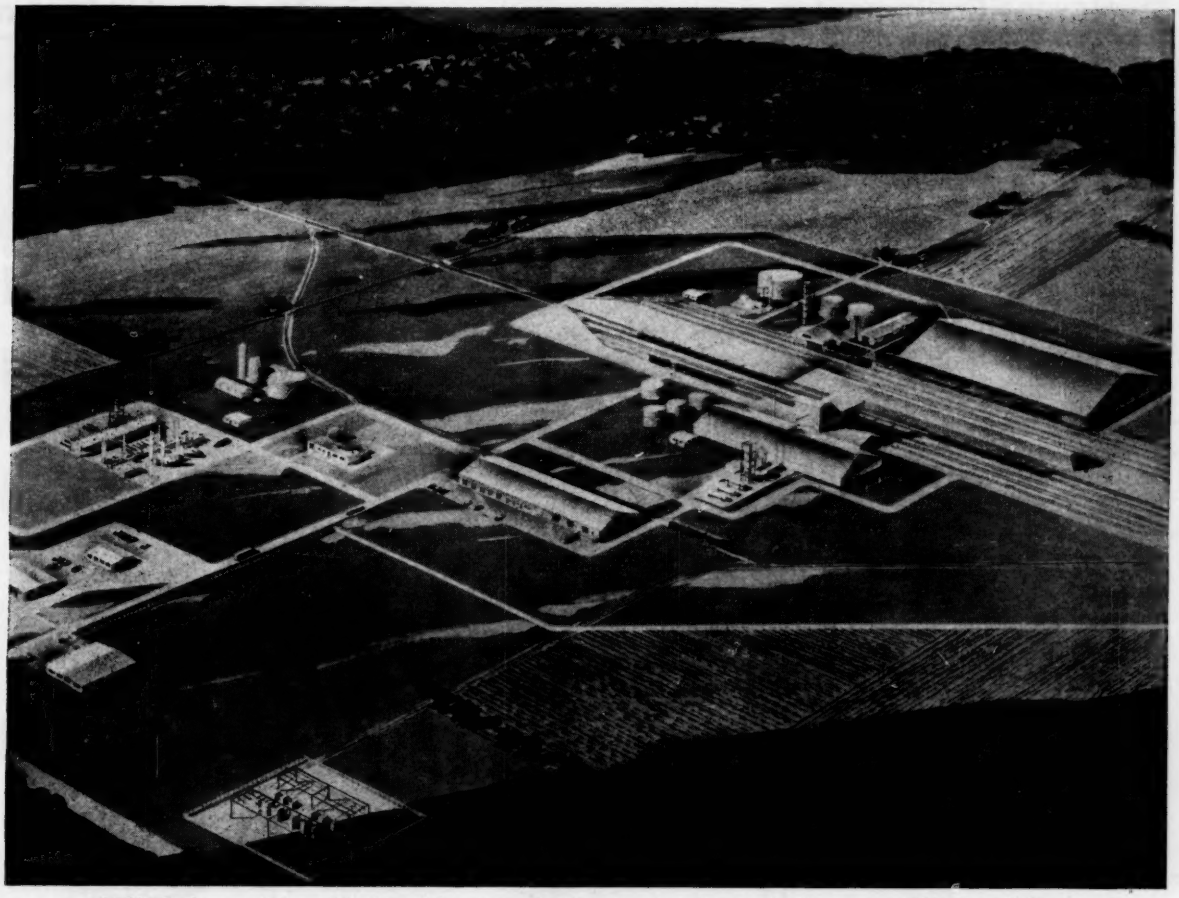
The metal-to-metal seal is said to grip tighter with increasing pressure. Called Dynatube, the coupling will seal liquids and gases up to 700 F.; it also withstands cryogenic conditions. Tested to 5,000 psi., the unit is capable of handling helium at least to that pressure.—**Resistoflex Corp., Roseland, N. J.** **138A**

Volumetric feeder

Scale-mounted, it controls flow, and records quantity of material.

A chemical feeder and loss-of-weight recorder are combined in this unit, to control dry-chemical flow precisely and provide permanent record of feeder operation.

Dry material is fed at a uniform rate that may be set from 0.0045 to 2.8 cu. ft./hr. A screw-type feeder



Architect's drawing of the multi-million-dollar nitrogen fertilizer manufacturing complex for Armour at Cherokee, Alabama.

Helping to Create the Cherokee Fertilizer Complex

The M. W. Kellogg Company has been given many assignments for the new multi-million-dollar nitrogen fertilizer manufacturing complex now being erected for Armour Agricultural Chemical Company at Cherokee, Alabama. Financed by the Town of Cherokee with a $25 million bond issue, the project will be leased to and operated by Armour.

Kellogg is engineering, procuring materials for, and constructing the 360-ton/day ammonia plant and the 50-ton/day urea plant. It will also be responsible for construction of all offsites. These include: utility and gas systems, power house, water pumping station, effluent disposal system; administration, maintenance, product storage, and service buildings; tankage, intermediate piping, and equipment utilized in offsites. In addition, Kellogg has a contract for engineering-management of the entire project.

This huge new fertilizer complex, which comprises six different plants on a 1200-acre site, is part of a $60 million expansion program currently being undertaken by Armour which will include a new phosphate plant to be erected near Fort Meade, Florida. When completed, in 1962, the chemical industries part of the Armour organization will represent more investment than the total for the meat producing facilities of the Chicago parent firm.

For information on Kellogg's background in fertilizers, write:

THE M. W. KELLOGG COMPANY

711 Third Ave., New York 17. *A subsidiary of Pullman Incorporated*

The Canadian Kellogg Company, Ltd., Toronto
Kellogg International Corporation, London
Societe Kellogg, Paris
Kellogg Pan American Corp., Buenos Aires
Compania Kellogg de Venezuela, Caracas
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Sturtevant Equipment NEWS

Vertical air-swept impact mill with integral air classifier

Sturtevant Pulver-Mill® does in one step what used to take two

Designed for fine grinding into the micron range and precise end product classification — all in a single operation, Sturtevant Pulver-Mills are proving highly effective for pulverizing soft to medium hard non-metallic materials. ■ *In Ag chemicals,* Pulver-Mills have helped one blue chip company enter and compete profitably in the lucrative 95% 325 mesh market . . . *In the milling field,* too, Pulver-Mills are increasing yield while also improving uniformity of particle size . . . *And pilot runs* at Sturtevant's laboratory indicate that Pulver-Mills can lower production costs, improve quality control, in the pulverizing of dozens of other materials. ■ Air-swept principle of operation (special intake vane design "whirls" vertical air flow) enables both control of attritional heat and integral air classification of end product. Precise selection of desired particle size is accomplished by an adjustable selector bar system. Unique deflector wall design "bounces" any partially reduced material back into the Pulver-Mill grinding zone — makes the reduction process (revolving impactors passing between fixed wall impactors) fast, highly efficient. ■ Now available in three models with capacities ranging from several hundred pounds per hour to 7½ tons per hour, Sturtevant will welcome the opportunity to test-run any soft to medium hard non-metallic material you may be working with.

For further information, send for Sturtevant Bulletin No. 093. Write Sturtevant Mill Co., 100 Clayton St., Boston 22, Mass.

STURTEVANT 85 years of design leadership in Air Classifiers, Micron-Grinders, Pulverizers, Blenders, Crushers, Grinders.

NEW EQUIPMENT . . .

prevents flooding, and built-in diaphragm agitators prevent bridging in the hopper.

The amount of chemical fed during any desired period may be recorded on 24-hr. or 7-day charts. A direct-reading register shows the amount of material remaining in the hopper at any time, and reports via a visual alarm when the hopper is depleted.

In combination with the feeder is a solution tank for mixing liquids with the chemicals. Liquid jets or an optional mechanical agitator help dissolve all the solids.— **Wallace & Tiernan, Inc., Belleville, N. J.** 138B

Control valve

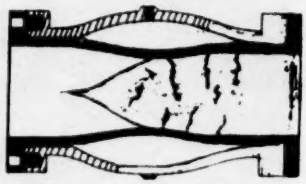
Unit completely drains line and valve body of flowing media.

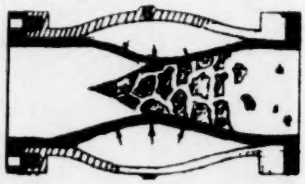
Body and trim of a new control valve are designed so that all surfaces slope downward, making it completely self-draining when installed either horizontally or vertically. Unit is electro-polished to provide smooth surfaces.

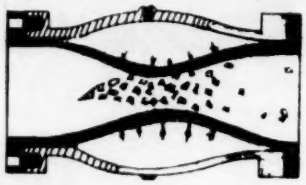
Principal applications are in batch systems that require frequent cleansing between runs, and in continuous processing systems that require purging of line and valves after shutdown.

The unit is available in ¼- through 6-in. sizes in carbon steel

Red Jacket Valves for "Lime Slurry Control"







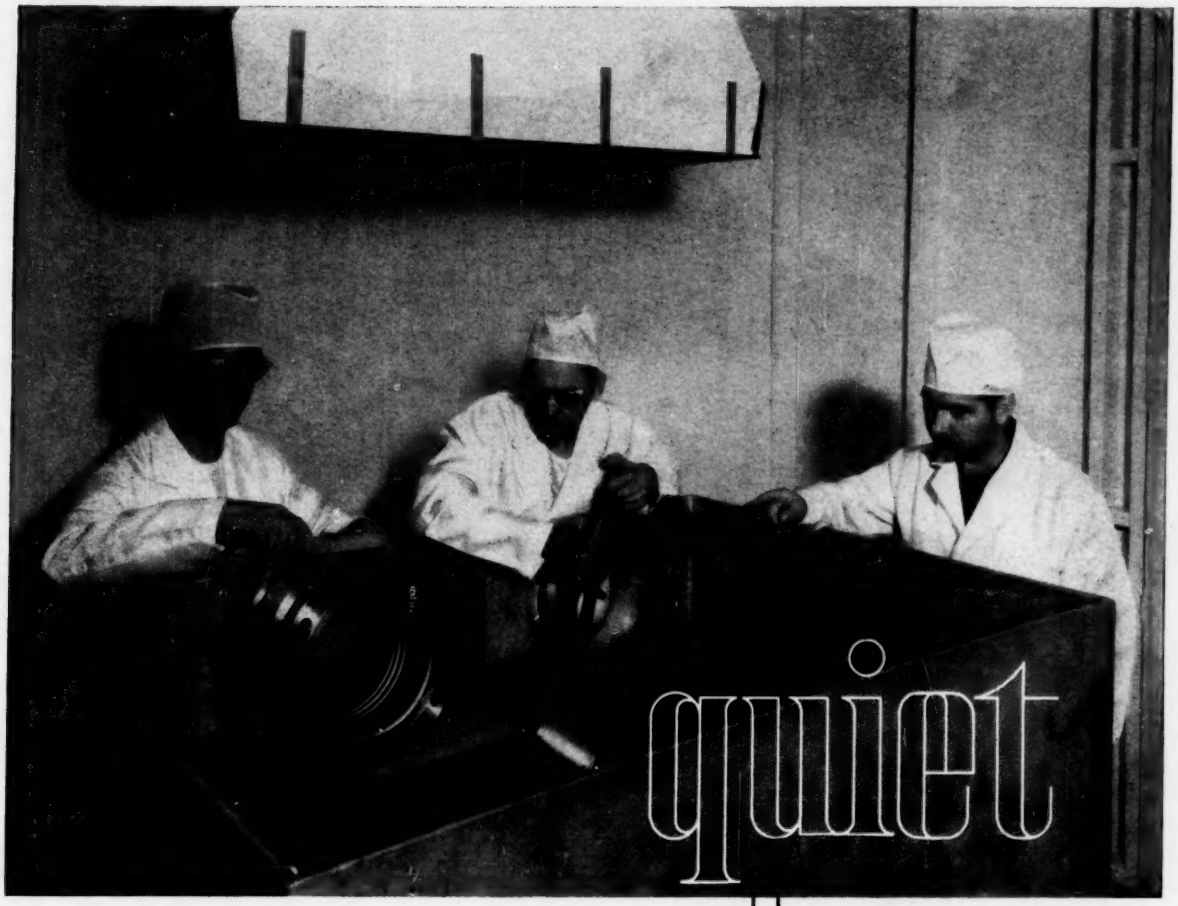
The sequence of pictures shows an air operated RED JACKET PINCH VALVE breaking a solid block of lime or clay which has solidified. The RED JACKET PINCH VALVE does not have to be removed from the line to remove the block. The sleeve opens up, permits the lump to pass and, also, breaks up the lime.

This is done in a matter of seconds, and therefore, good control can still be maintained.

Other advantages of the RED JACKET PINCH VALVE for this service are the fact that the soft rubber sleeve resists the abrasive and corrosive action of the lime.

Red Jacket Company, Inc.

BELL AVENUE CARNEGIE, PA.



quiet please

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and various alloys. Control may be linear, percentage or semi-throttle, for all types of actuating systems.—**The Annin Co., Div. of The Worthington Corp., Montebello, Calif.** **140A**

Briefs

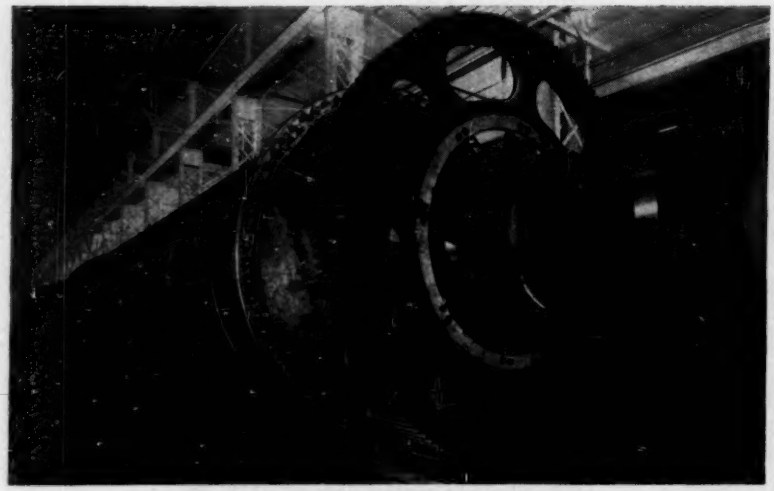
Vibratory feeder has its exciting force amplified by the resonance action of heavy-duty shear springs, to develop maximum vibration. Adjustable-rate models use air springs to vary stroke and speed rate. Capacity of adjustable or fixed-rate models: up to 750 tons/hr. — **General Kinematics Corp., Barrington, Ill.** **142A**

Cryogenic thermometer measures the range from 0.3 to 24 K. without need for special compensation. Values are read directly on a calibrated scale to extreme accuracy, reports the manufacturer. — **Malaker Laboratories, Inc., Mountainside, N. J.** **142B**

Equipment Cost Indexes . . .

	Dec. 1960	Mar. 1961
Industry		
Avg. of all	237.3	237.2
Process Industries		
Cement mfg.	231.6	231.3
Chemical	238.1	238.0
Clay products	225.1	224.8
Glass mfg.	224.8	224.7
Paint mfg.	229.4	229.7
Paper mfg.	229.4	229.3
Petroleum ind.	234.3	234.7
Rubber ind.	237.1	237.6
Process ind. avg	236.1	235.9
Related Industries		
Elec. Power equip.	238.3	237.9
Mining, milling	239.5	239.4
Refrigerating	268.0	268.5
Steam power	224.5	224.9

Compiled quarterly by Marshall and Stevens, Los Angeles, for 47 different industries. See Chem. Eng., Nov. 1947, pp. 124-6 for method of obtaining index numbers; Mar. 6, 1961, pp. 115-116 for annual averages since 1913.



Ruggles-Coles
ROTARY COOLERS IN FOUR TYPES

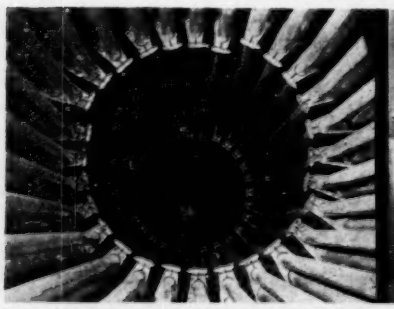
GAS-COOLED TYPE—Solids are cooled by direct contact with cooling air (atmospheric, or dried and refrigerated). Inert gases may be used in a closed system.

WATER-COOLED SHELL—Water is externally applied to the shell, either by sprays or by partially submerging the shell.

TUBULAR TYPE—Internal water-cooling tubes are assembled with the rotating shell, or installed as a stationary bank of tubes concentric with the shell. Alternately, the water leaving either of these tube sections may be used for supplemental spray cooling on the shell exterior.

DIRECT-CONTACT WATER—For rapid cooling from very high temperatures, water is sprayed directly on the hot material to utilize the latent heat of vaporization. Usually supplemented by secondary air cooling.

Each of these types has a particular area in which it is most economically applied. Write for further information.



Interior of a water-tube cooler. Longitudinal banks of tubes provide maximum cooling surface for minimum floor space.

Interior of partially-submerged cooler with gravity-controlled scrapers maintaining clean shell surface for high-rate heat transfer.

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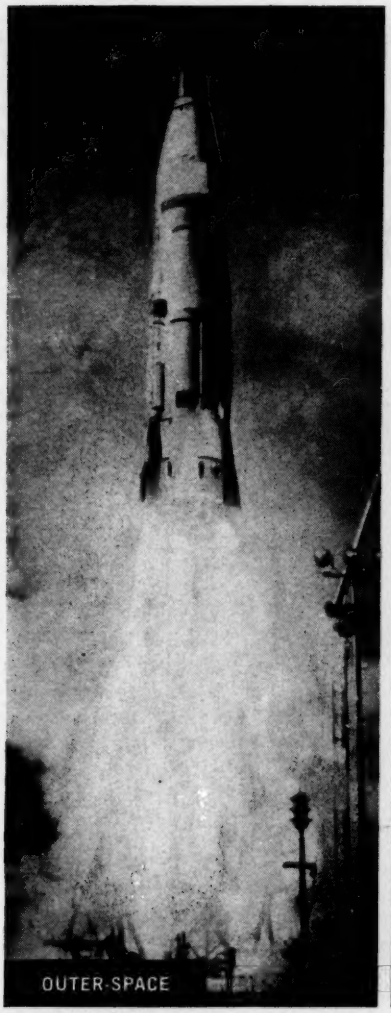

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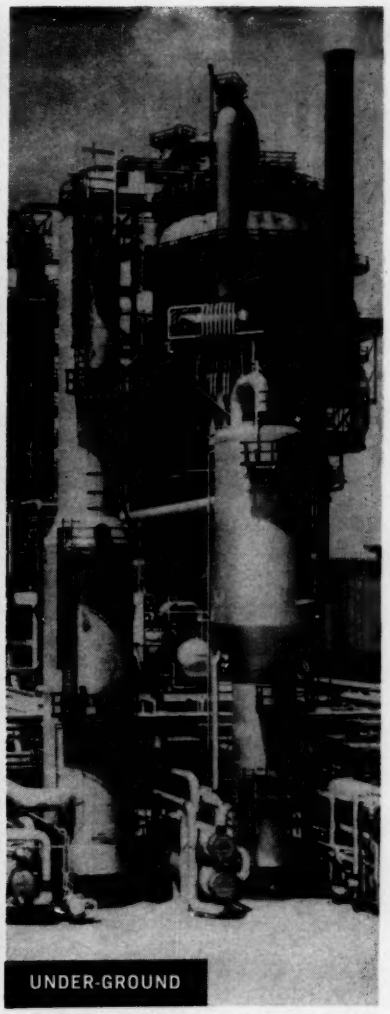

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OUR PRODUCTION *TODAY* ACCOMPLISHES *TOMORROW'S* PLANS

NORWALK COMPRESSORS have many construction and design features which combine to make them most rugged for the highest operational efficiency with the minimum of maintenance.

Whatever your compression requirements, from single stage to six stages, from 0 to 42,000 psi pressures, for all gases and air, *NORWALK COMPRESSORS* can do the job.

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Gulf Oil Corp.
Air Reduction Co., Inc.
Allied Chemical Corp.
Aluminum Corp. of America
Atlas Powder Co.
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Baldwin Lima Hamilton Corp.
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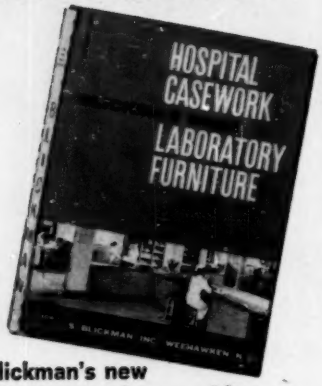
specify BLICKMAN-BUILT laboratory furniture and hospital casework!



Blickman's new 40-page catalog provides a quick-reference implement for basic planning of laboratory and hospital installations.

It includes specifications for **standard and specialized laboratory furniture, and fixtures**... PLUS details of Blickman's exclusive **CONFLEX** construction. This new concept achieves maximum flexibility of door and drawer arrangements, without the use of tools ... and without loss of rigidity or structural soundness!

More than 75 years of manufacturing experience stand behind the famed Blickman-Built symbol. It identifies the finest in stainless and enameled steel equipment!

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Technical Bookshelf

A CLEAR SUMMATION

VISCOELASTIC PROPERTIES OF POLYMERS—1961. BY JOHN D. FERRY. WILEY. 482 PAGES. $15.

Reviewed by V. L. Folt, Senior Research Associate. The B. F. Goodrich Co.

Viscoelasticity is often considered a rather obtuse subject, and chemical engineers who feel a need for wider knowledge lament that most books on the subject are of little value to them.

With the advent of many plastics as recognized materials of construction, coupled with the widespread commercial use of elastomers, the need for a coherent treatise on this subject has been apparent. Professor Ferry has done an admirable job of gathering into a single book information that has been widely scattered throughout the literature.

The phenomenological theory of linear viscoelasticity is briefly but adequately treated. A rather wide selection of experimental techniques is presented, and areas of applicability as well as limitations are discussed. An attempt to relate the experimental measurements to prevalent molecular theories comprises a large portion of the text and this section is particularly good.

Existing literature has been well covered and all chapters contain a wealth of references for those interested in additional details. Of particular value is that pertinent equations are found where needed —or are appropriately referred to— rather than only in the chapter where they are developed. Inadequacies in the theories, particularly in the practically important areas of high deformation, are stressed. It is regrettable that all work on capillary melt rheology has been omitted even though theory lags far behind experimentation in this area.

Two additional features are outstanding. One chapter is devoted to applied calculations illustrating the practical use of the various functions developed and should prove to be a popular feature of

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Is messy carbon feeding giving you a headache? Costly housekeeping and employee health problems cutting your profits?

Whether you're feeding floodable carbon (smoke) or free flowing granular carbon, organic or mineral carbon, B-I-F's totally enclosed feeding systems provide automatic, continuous control of the flow of this hard-to-handle material . . . at high accuracy. Regardless of material characteristics or process conditions, B-I-F has the performance-proved, engineered system for more efficient carbon feeding.

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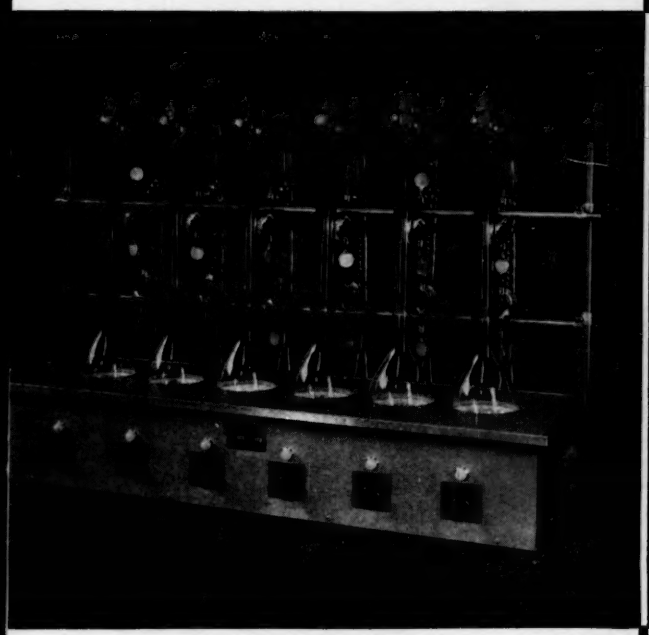
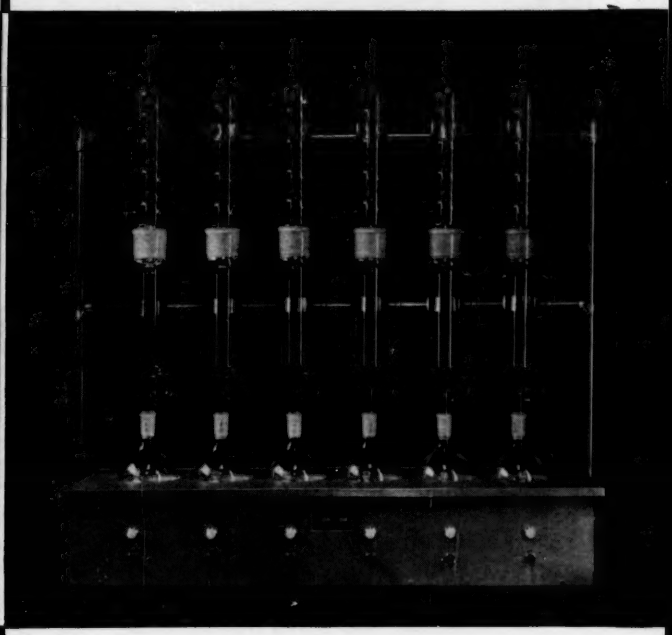
Two new heating mantles from Glas-Col

The new Soxhlet and Kjeldahl heating mantles are by-products of years of Glas-Col research in the development of safe, dependable heating equipment for pilot plant and laboratory use. Nothing has been overlooked for the safe operation of this equipment. Both new units have a beautiful anodized aluminum housing which holds six flasks. Tops are made of a resilient cork-like material to help prevent accidental mechanical flask breakage. Heating units can be individually replaced, if severely damaged by spillage of chemicals, at reasonable cost.





Kjeldahl Heating Mantle

Heat input for each unit can be individually controlled. The mantle has rugged 3-wire cord with one wire grounded to metal housing. Since wattage requirements for distilled aqueous solutions are high, the heating mantles are made from quartz fabric for safe, dependable operation.

SPECIFICATIONS

Catalog No. KJ-500	
Size of flask	500 ml
Power per unit	325 watts, 115 volts
Price	$350.00
Replacement heating elements	$12.00 each
Catalog No. KJ-650	
Size of flask	650 ml
Power per unit	385 watts, 115 volts
Price	$370.00
Replacement heating elements	$14.00 each
Catalog No. KJ-800	
Size of flask	800 ml
Power per unit	440 watts, 115 volts
Price	$370.00
Replacement heating elements	$14.00 each

Soxhlet Heating Mantle

Since flammable solvents are most always used in Soxhlet extractions, this new heating mantle has been designed with utmost safety in mind. It utilizes Powerstat type control and is provided with rugged 3-wire cord, one wire grounded to housing.

SPECIFICATIONS

Catalog No. SOX-500	
Size of flask	500 ml
Power per unit	250 watts, 115 volts
Price	$285.00
Replacement heating elements	$9.50 each

Prices for other sizes on request.
Wire, write, or phone today for complete details.

Glas-Col Apparatus Company

Dept. CR, 711 Hulman Street, Terre Haute, Ind.

World's largest manufacturer of heating mantles for laboratory, pilot plant, and production applications.

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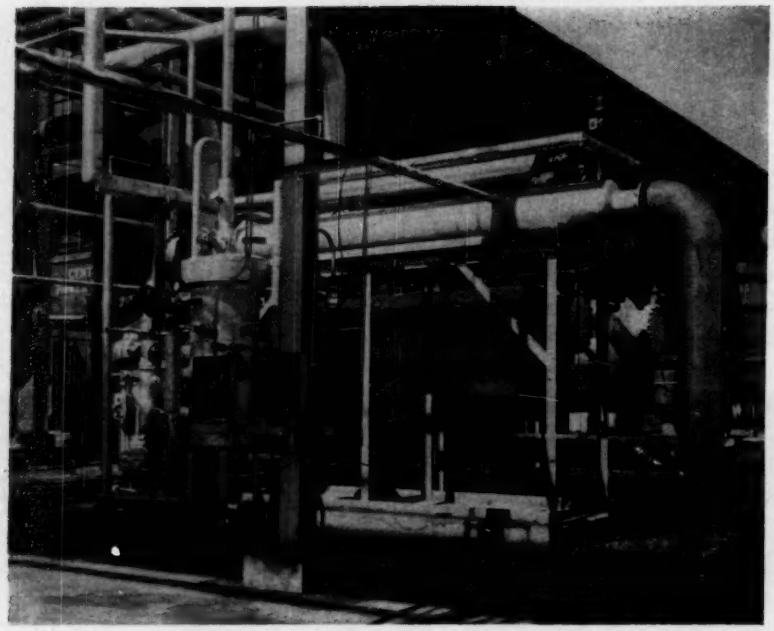


AT ESSO'S BAYWAY REFINERY...

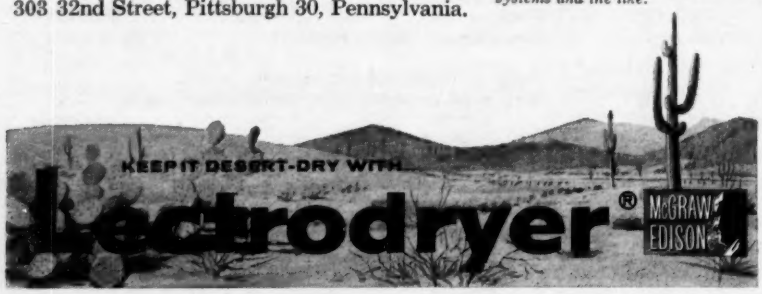
Central Lectrodryer serves entire plant, keeps instrument and tool air desert-dry

A steady flow of moisture-free instrument air is essential to smooth-running refinery operations. Lectrodryers have long been used at the Bayway Refinery of the Esso Standard Division of Humble Oil and Refinery Company, Linden, New Jersey, to control moisture content in individual instrument systems. But the addition of new instruments, more controls and air-driven tools eventually overtaxed the combined capacity of the individual dryers.

Esso has recently installed a single, central Lectrodryer, from which dry air is piped throughout the entire plant. In addition to year-round protection against instrument freeze ups, this system provides ample additional air to operate air-driven tools without the need of anti-freeze; means better tool lubrication, longer tool life. Moreover, there is neither air nor maintenance time wasted in bleeding lines dry.

Investigate the benefits of such a Lectrodryer system by writing for case history sheets illustrating in detail specifications and solutions to a multitude of moisture problems. Pittsburgh Lectrodryer Division, McGraw-Edison Co., 303 32nd Street, Pittsburgh 30, Pennsylvania.

Lectrodryer's wide range of drying apparatus also includes this budget model, which delivers small quantities of extremely dry air for wave guides, small cubicles, instrument systems and the like.



the book. Another feature is the inclusion of examples of numerical data for dynamic and relaxation moduli. Examples of such data are rare even in the literature, where they are usually presented in graphical form.

Presentation of the subject is sufficiently straightforward that investigators encountering the phenomena of polymer viscoelasticity for the first time could use the book to familiarize themselves with the subject. Thus, a laudable objective in writing the book has been achieved. Nevertheless, rather diligent efforts on the part of the novice will be required to grasp the intricacies of the subject. This is certainly not a work for the casual reader.

Despite its relatively high cost, the book is recommended as an addition to the personal library of all types of engineers. It presents a well-documented, clearly written summation of a difficult and complicated subject that is assuming a high degree of technological importance.

And Also Received

Conversion Factors and Tables. By O. T. Zimmerman and I. Lavine. 680 pages. In its third edition, this small (4¼ x 6¼-in.) but thick (1¼-in.) handbook converts just about everything into just about everything else. Besides conversion factors among physical measurement units, volume tabulates such things as standard sieve sizes, five-place logarithms, Mohs' Scale of Hardness, physical absolute constants, and various equations from geometry and algebra. Its Fahrenheit/centigrade conversion table moves in uniform steps no smaller than full degrees, however; and while some units of foreign currency are listed, no international rates of exchange appear. Price: $7.50. Write: Industrial Research Service, Masonic Bldg., Dover, N. H.

More New Books

Partition of Cell Particles and Macromolecules. By P.-A. Albertsson Wiley. 231 pages. $7.

The Encyclopedia of Microscopy. Ed. by G. L. Clark. Reinhold. 693 pages. $25.

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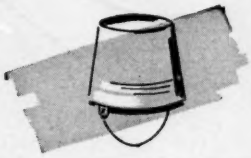

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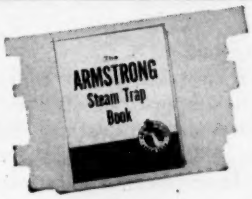

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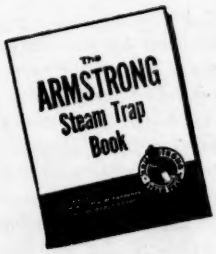

The 48-page Armstrong Steam Trap Book tells how to correctly size, install and maintain steam traps for any pressure, any temperature, any load plus full catalog data on Armstrong Steam Traps. Ask for Catalog K.

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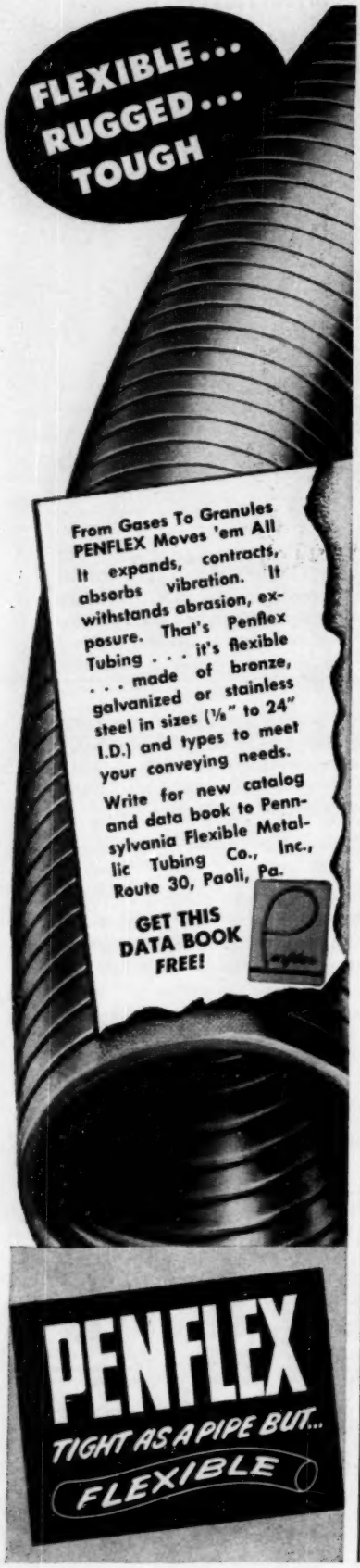
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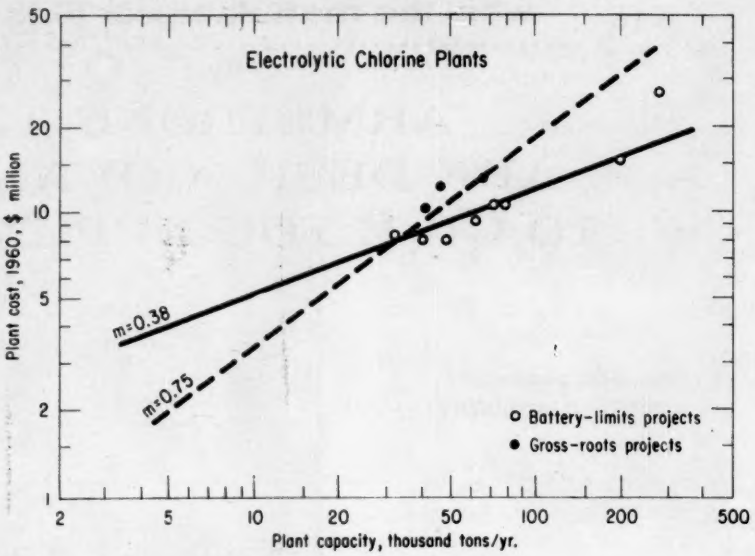

What Is Proper Slope of Cost-Capacity Curve?

Sir:

In CE Cost File No. 50 (Mar. 20, p. 182), there is a chart giving cost-capacity data for chlor-alkali plants.

The slope of the curve is wrong. The capacity exponential factor for electrolytic caustic-chlorine plants should be approximately 0.75, not the 0.38 slope in your Cost File chart. This can be readily seen from the following facts:

For cell house and contents, $m = 1.0$.

For process facilities for cell feed and recovery of products, $m = 0.6$, approximately.

For electrical power conversion, $m = 0.8$, approximately.

For complete, standard, battery-limits chlor-alkali plants, experience has shown the over-all exponent to be 0.75. The over-all value of m for diaphragm-cell plants is probably a little less than 0.75. For mercury-cell plants, there could be a break in the curve at some point where outsize cells are adopted at perhaps 150 tons/day of chlorine and over.

We do check your curve, however, at 100 tons/day (36,000 tons/yr.) of chlorine, where 1960 cost is $8.5 million.

R. B. MACMULLIN
R. B. MacMullin Associates
Niagara Falls, N. Y.

Sir:

The point raised by Mr. MacMullin is certainly a legitimate one and can best be illustrated by the above graph. The indicated points all represent plants actually in existence. Six of the points are from our own files, the other five from the published literature.

Slope of the curve is a matter of interpretation. A curve of any slope between 0.38 and 0.75 might reasonably fit the data. The value of 0.38 seemed to be the best fit for the installations on which we had the most reliable investment figures. At the same time, we realize that others active in the field have figures which differ from ours and which serve to show that considerable latitude can exist costwise in any volume production of a given chemical.

JOHN E. HASELBARTH
Pritchard & Abbott
Houston, Tex.

▶ *Mr. MacMullin's position is strongly supported by an analysis of chlorine plant costs by Bryce P. Schofield, published originally in* CE *in Oct.* 1955 *(p.* 185*) and recently reprinted in "Cost Engineering in the Process Industries." Mr. Schofield arrived at a cost-capacity exponent of* 0.75*, exactly what Mr. MacMullin predicts by synthesis*

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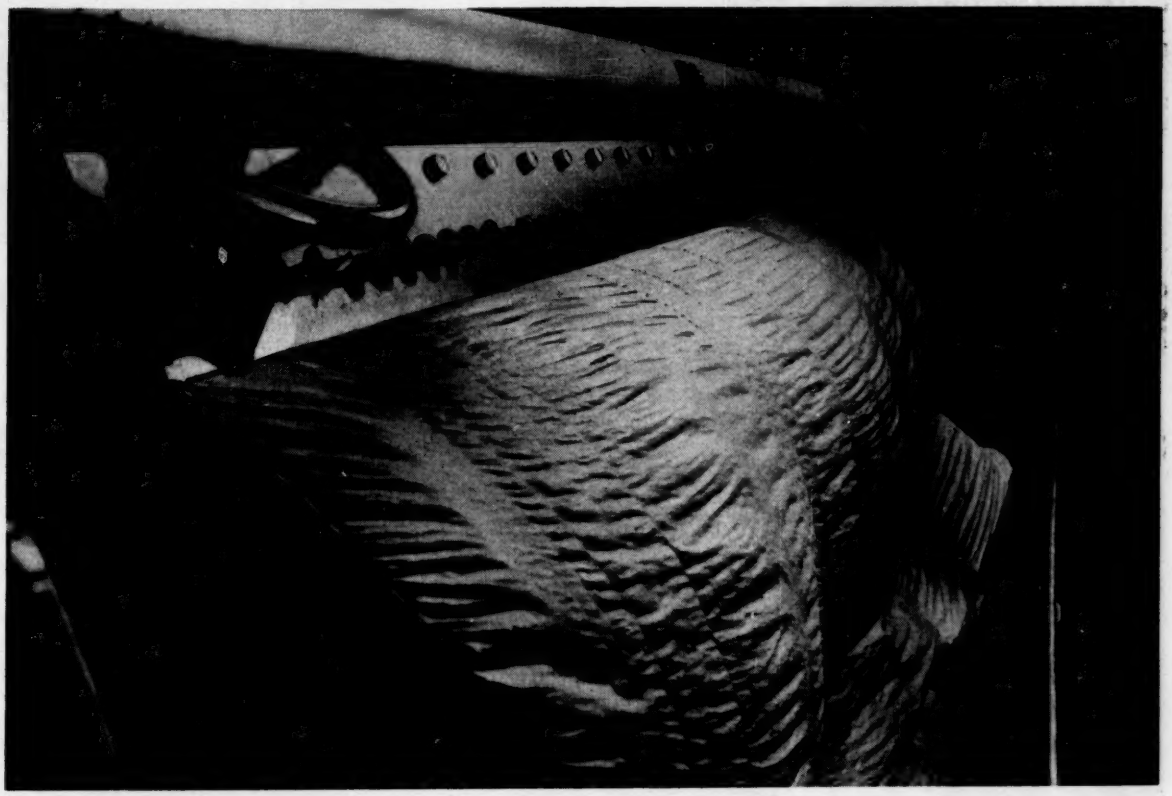

Is drying your problem?

A sheet of dry material as it leaves one of the drums of a Buflovak Double Drum Dryer.

Buflovak Atmospheric or Vacuum Double Drum Dryers are successfully drying a wide variety of materials. These materials may be dilute or heavy liquids of various densities and viscosities, including slurries, pastes and sludges. Proven drum dryer feeding distribution systems are available for these widely different types of materials.

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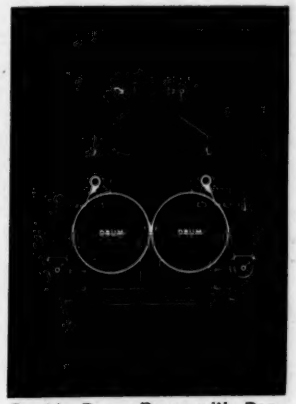
Film thickness on the drums is accurately controlled by regulating the clearance between them. The product dries rapidly, without being subjected to high temperatures for long periods.

Buflovak makes other types of Drum Dryers, including Single or Twin Drum for atmospheric or vacuum operation. In addition there are Vacuum Rotary and Vacuum Shelf Dryer types. Recommendations are based entirely on the type of dryer best suited to the product requirements. If special equipment is required, let Buflovak engineers design it for you. Send for Catalog 384 for the full story.

Our Customer Technical Service Laboratory solves a processing problem for someone every day

We have a completely equipped Laboratory that can help you get answers to your new drying problems or, perhaps, improve your present product. We do this for many companies. We can do it for you too. Call or write for Catalog 381 describing available facilities. Buflovak Equipment Division, 1551 Fillmore Avenue, Buffalo 11, New York.



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PRO & CON . . .

from the elements of plant cost. To avoid the inconsistencies of grass-roots vs. battery limits, diaphragm cell vs. mercury cell, gaseous product vs. liquid product, etc., Mr. Schofield used a special method of plotting, which we commend to cost engineers seeking valid cost-capacity correlations.—ED.

New Cross-Linking Catalyst

Sir:

In your Feb. 20 issue (p. 225) you published a letter from E. R. Gilmont of Food Machinery & Chemical Corp. which refers to statements made earlier in your magazine about Lucidol catalysts for cross-linking polyethylene.

Mr. Gilmont is only partially correct. The particular catalyst he mentions was found soon after its commercial introduction to cross-link prematurely during compounding with high-density linear polyethylene of high melting point.

In 1960 we introduced a new and different material, 2,5-dimethyl-2,5-di (*t*-butyl peroxy) hexyne-3 under the trade name Luperco 130-XL. This is a higher-temperature catalyst, and we have specifically recommended it for high-density linear polyethylene. First reference to this new chemical for cross-linking linear polyethylene was made in your *Chementator* column, June 13, 1960.

RICHARD M. BERRY
Lucidol Div.
Wallace & Tiernan Inc.
Buffalo, N. Y.

Pro: Trade Secret Truths

Sir:

A. W. Gray's article, "Is Your Trade Secret Really a Trade Secret?" (Jan. 9, pp. 120-2), is not only of immediate usefulness in our class work, but it has attracted a great deal of attention from other people within the engineering department.

H. S. BUSBY
University of Hartford
Hartford, Conn.

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* Don't forget to check the Free Reprint box for your extra copy of this issue's reprint feature (p. 77)

permanent magnetic force...

A sleeve, raised and lowered within a nonmagnetic tube, attracts or releases an Alnico magnet attached to the mercury (or dry contact) switch. Basically, this is Magnetrol.

The operating principle behind MAGNETROL LIQUID LEVEL CONTROL

Because its operating principle, based on the proper use of a permanent magnet, guarantees a perpetual guardianship over your critical liquid levels, the Magnetrol liquid level control unobtrusively takes the most important place in any system or process where it is necessary to keep a liquid at a constant level. Principle and action are so simple that failure is virtually impossible. Magnetrol is versatile, too—will handle almost ANY liquid, at ANY temperature, at ANY pressure, with the same precision and dependability. No mechanical or electrical linkages to stick, bind, ride out of line or wear out. Available for controlling level changes from ⅛" to 150 ft. Multi-stage switching when desired. Write to

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Working pressures to 10,000 psi.
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Working pressures to 6,000 psi.
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Working pressures to 10,000 psi.
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Three great series of needle throttling valves—designed and built as only Marsh experience *in both* valves *and* instruments can make them. In materials for extreme range of services. In a full range of sizes and patterns, including panel mounted. For a wide range of pressures and temperatures.

Body and stem guides machined from solid bar stock for extra strength. Precision ground stems with fine pitched stem-threads for close regulation—tight shut-off. Long lived, but easily replaced "Marpak" moulded packing; Teflon in stainless steel valves. Deep inlet and outlet threads for tight make-up.

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Chemicals

Acrylates.....are made by beta propiolacetone process to give you unexcelled purity of product. Further information and technical literature is available.
51 *Celanese Chemical Co.

Aldehyde Analysis.....New methodology for continuous, automic analysis of aldehydes is outlined in 2-page data sheet that includes a flow diagram to show each step.
154A Technicon Controls, Inc.

Anhydrous Sodium Bisulfite.....is an economical dry source of SO_2 for use as a reducing agent. It is exceptionally pure with high strength. Facts are available.
39 *Allied Chemical, Gen. Chem. Div.

Carbon Dioxide.....Around the clock service for delivery of carbon dioxide in any form or in any quantity. An informative booklet is available.
128 Olin Mathieson

Chemical Catalog.....1961 catalog contains a complete listing of more than 400 reagents in addition to descriptive data on other laboratory chemicals and solvents.
154B Mallinckrodt Chemical Works

Chromium Chemicals.....For a full description of Mutual chromium chemicals, uses, properties & comprehensive technical data, see Bulletin 52 which is offered.
55 *Solvay Process Div., Allied Chem.

Epoxy Resin.....Flame-retardant epoxy resin for hot-melt castings and dry lay-up laminating systems is described in brochure that includes tables for various properties.
154C Union Carbide Plastics Co.

Fluorides.....Company offers a copy of M. C. A. Chemical Safety Data Sheet SD-25 on properties & essential information about hydrofluoric acid, anhydrous & aqueous.
64 *The Harshaw Chemical Co.

* From advertisement, this issue

Phosphate Determination.....2-page data sheet outlines newly-developed procedure for continuous, automatic determination of phosphate content of phosphate rock.
155A Technicon Controls, Inc.

Plastic.....Kel-F plastic performs through an unusually wide temperature range. It has high tensile & compression strength. Further information is available.
49 *Minnesota Mining & Mfg. Co.

Plastic Flow.....Pamphlet "The Real Flow-Behavior of Plastic Substances" by Dr. A. G. Epprecht is a complete technical discussion of the viscous deformation of plastic substances.
155B Drage Products Inc.

Propylene Glycol.....Brochure gives properties, toxicity and provides extensive solubility data in tabular form of chemical used in food, beverage and cosmetic industry.
155C Jefferson Chemical Co.

Rare Earths.....8-page brochure contains complete technical information on thorium, yttrium chemicals and metals and alloys of the rare earth group of elements.
155D Vitro Chemical Co.

Solvent.....Samples and information on Pent-Oxone solvent including complete graphs on viscosity and evaporation and its keto-ether action are available on request.
34 *Shell Chemical Co.

Urethane Foam.....Rigid urethane foam made with Hylene is easier to apply and has double the insulating capacity of ordinary insulation. Information is available.
22-23 *E. I. DuPont de Nemours

Construction Materials

Alloy Selector Chart.....Chart, designed to aid semiconductor engineers in selecting proper alloy, lists 56 different alloys in order of solidus and liquidus temperatures.
155E Accurate Specialties Co.

Want to build up your files and keep them up-to-date? You can get any publication in this comprehensive guide — free — just for the asking.

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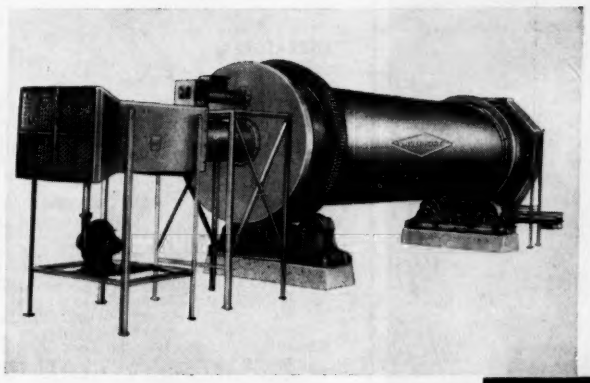

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5'-0" x 24'-0"

Now in use — Finish drying whey powder (food product). Made from stainless steel. Finest for food processing. Second installation in major Minnesota cheese plant.

Let our engineers consult with you on your Pressing, Drying and Cooling problems or send for our catalog A. For quick reference consult your Chemical Engineering Catalog.

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ROTARY DRYERS
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ROTARY COOLERS
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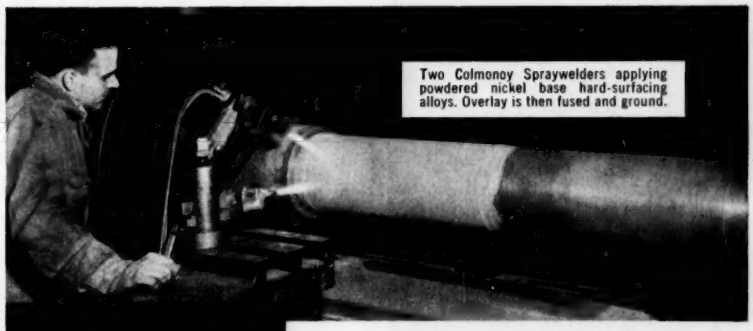

Two Colmonoy Spraywelders applying powdered nickel base hard-surfacing alloys. Overlay is then fused and ground.

Mixer Stub Shaft Gets Fast Protection

Photo: New England Hard Facing Co.

COLMONOY HARD SURFACING STOPS EXCESSIVE CORROSION / ABRASION

Highly corrosive and abrasive slurry in a drug fermenter demanded a wear resistant mixer shaft. The Sprayweld Process was used to overlay the wear area with Colmonoy No. 6 hard-surfacing alloy. This cut the time required from 72 hours (using manual rod welding) to only eight hours. The Colmonoy overlaid shaft outlasts 24 unprotected nickel-alloy shafts.

Investigate non-galling, near-frictionless Colmonoy overlays as a means of reducing excessive wear on your process equipment. Ask for the Colmonoy Spraywelder Catalog.

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LITERATURE . . .

Alloys.....Spraywelder process of hard surfacing stops excessive corrosion and abrasion. For further information on this hard-surfacing alloy, the Spraywelder Catalog is offered.
B155 *Wall Colmonoy Corp.

Ceramic Catalyst Carriers.....Size, weight, porosity, & purity are held to close tolerance. Carriers are described in detail in bulletin "Keys to Better Catalysis".
25 *Norton Company

Coating.....Penton is now used in many forms for all types of chemical processing equipment. "The Penton Buyer's Guide" is available on request.
69 *Hercules Powder Co.

Cobalt-Base Alloy.....Research report contains data on the structure, room temperature tensile strength and 100 hour stress-rupture strength at 1600 and 1800 F.
156A Cobalt Information Center

Construction Material.....Koroseal PVC won't corrode, can't rust, is easy to fabricate and install. A catalog is available describing its many advantages.
1 *B. F. Goodrich

Filter Fabrics.....offer maximum chemical and heat resistance, high abrasion resistance, and efficient cake retention-and-discharge properties.
122 *United States Rubber

Floor Coating Primer.....Bulletin describes primer that can be used on damp concrete surfaces and is resistant to acids, alkalis, oils and solvents and offers thermal shock resistance.
156B Pennsalt Chemicals Corp.

Insulation.....The new Industrial Insulation Catalog is offered. Also Data Sheets on the complete line of accessories for use with Foamglas insulation.
103 *Pittsburgh Corning Corp.

Metal Fabrication.....No matter how large or small, how intricate or complex, all types of metals can be fabricated. Further details are available on request.
101 *The Boardman Co.

Plastic Welders.....Bulletin contains detailed information on complete line of welders for thermoplastics. Welders are designed to weld, seal, tack and repair.
156C Golden Plastics Corp.

Plating.....Brochure highlights variety of high-performance original and replacement plating cylinders, superstructures, tanks and components to fit all makes of barrel equipment.
156D Singleton Co.

Seals and Packings.....Catalog describes and illustrates types, sizes, operating features and advantages of complete line of solid urethane hydraulic seals and packings.
156E Disogrin Industries

Electrical & Mechanical

Cable & Terminal Boxes.....Thermo-Cable terminated in a weather-proof multi-terminal box offers increased efficiency & economy. Details are contained in Catalog 83-4
L126 *Thermo Electric Co.

Controlled Speeds.....Brochure describes controlled speeds systems that permits motors to start stop accelerate to full speed and accept speed adjustment while running.
156F U.S. Electrical Motors, Inc.

Couplings.....for every operation that calls for quick, tight connections. Available in brass, malleable, stainless, aluminum, etc. Details in illustrated Catalog C-11.
45 *Ever-Tite Coupling Co., Inc.

Motors.....Crocker-Wheeler motors, from smallest to largest, are offered in all conventional enclosures and modifications with insulation to suit the application.
24 *Elliott Company

Pressure Switches.....Data sheet describes a leak-proof, adjustable pressure and differential pressure switch for use in fluid systems operating at up to 250 psi.
156G Pall Corp.

Rectifiers.....as well as complete semi-conductor power conversion equipment and systems for any AC to DC application. "Guide" to Industrial Rectifier Equipment.
65 *The Meaker Co.

Selector Switches.....New thermocouple selector switches for accurate indication of temperature in many applications. Details are to be found in Catalog 24-4.
R126 *Thermo Electric Co.

Starters.....Information about the new line of across-the-line starters is contained in the new Publication 6100 which is available on request. All in smart new enclosures.
67-68 *Allen-Bradley Co.

Switch.....Data sheets describes limit switch that operates 4 circuits with each direction of the lever, and can be adjused to operate in sequence. Dimension drawings included.
156H Micro Switch Div.

Transformers.....New line of Class H Dry-Type Transformers offering drastically reduced size, weight, and audible sound levels are described in bulletin 162.
156I Niagara Transformer Corp.

Turbines.....Type YR turbines are tightly sealed against heat, cold, dust, fumes, rain & snow. Many key parts are interchangeable for various frame sizes. Bull. H22-D.
129 *Elliott Co.

Handling & Packaging

Belt Conveyors.....for small or large tonnages, for route of any length. Pre-Bilt sectional belt conveyors are also available. Catalog is offered.
18-19b Link-Belt Company

Bucket Elevators.....Complete line includes 14 types in 4 basic designs centrifugal, positive, continuous, & internal discharge. Factory-aligned components available.
18-19c *Link-Belt Co.

Conveyor Takeups.....16-page booklet 2741 describes complete line of over 320 takeup units in seven frame styles and equipped with sleeve, ball or roller bearings.
156J Link-Belt Co.

* From advertisement, this issue

Cryogenic Storage Vessels.....assure negligible boil-off. Brochure G-50, Cryogenic Storage Vessels" is available on request for more complete information.
53 *Chicago Bridge & Iron Co.

Electronic Weighing.....24-page brochure 161-B29 written in Spanish and English presents instrumentation for use in batching and tank weighing applications.
157A Streeter-Amet Co.

Feeder.....Brochure describes feeder that continuously weighs and feeds any dry, flowable material at a fixed rate with a maximum of two cu. ft. per minute.
157B B-I-F Industries

Oscillating conveyors.....All four types of oscillating conveyors provide surge-free movement of materials. Catalogs are available on request.
18-19d *Link-Belt Co.

Payloader.....Model H-25 Payloader offers extraordinary protection such as cartridge-type oil filters. A booklet "Industrial Materials Handling from A to Z" is offered.
31 *The Frank G. Hough Co.

Pneumatic Conveyor.....2-page bulletin describes and illustrates a portable unit that features a positive pressure constant displacement blower of high efficiency.
157C Fuller Co.

Portable Transfer Units.....Portable Airveyor transfer units provide flexible, lower-cost handling to & from cars, trucks, etc. Information is Bulletin A-23.
132 *Fuller Company

Screw Conveyors.....are easily adapted to congested locations & operate horizontally, vertically or inclined. Catalog is available for details.
18-19a *Link-Belt Co.

Heating & Cooling

Aftercoolers-Heat Exchangers.....Bulletin contains information on 15°, 10°, an 2° aftercoolers, shell and tube heat exchangers and lists data and prices of compressed air filters.
157D R. P. Adams Co. Inc.

Burner Units.....These gas firing burner units can be supplied with a medium pressure gas pilot for electric ignition. Literature & technical & engineering data offered.
117 *National Airoil Burner Co.

Burners.....Gas-fired infra-red burners designed for low-temperature commercial and industrial process heating are described in bulletin that gives selection and sizing information.
157E Eclipse Fuel Engineering Co.

Extruders.....Thermatic Series extruders have capacity to permit high heat application, ample cooling along the barrel and higher head pressure. Facts are available.
150 *Davis-Standard

Heat Exchanger.....2-page bulletin describes heat exchanger series that features removable bundles with floating clamp-ring design and discusses engineering specifications.
157F American-Standard Industrial Div.

Heat Exchanger.....8-page catalog on new impervious graphite counter-flow block heat exchanger gives dimensions and fluid flow patterns. Typical mounting methods are also shown.
157G National Carbon Co.

Heat Exchangers....feature wide range of shell sizes, surfaces and pressures to meet all but the most unusual requirements. Full details are contained in Bulletin 101.
63 *Griscom-Russell Company

Heat Transfer.....4-page bulletin covering automatic electric fluid heat transfer systems contains drawings, specifications and descriptive copy on various models.
157H Radcor, Inc.

Heaters, Circulation.....Catalog 60 gives full data and uses for Chromalox electric circulation heaters for anything that's piped and is available on request.
134 *Edwin L. Wiegand Company

Heating Mantle.....Kjeldahl heating mantles are described in detail in Catalogs KJ-500, KJ-650 and KJ-800 and may be had upon request.
145a *Glas-Col Apparatus Company

Heating Mantle.....Soxhlet heating mantles are designed for utmost safety. Catalog No. SO-500 gives specifications and prices and is available on request.
145b *Glas-Col Apparatus Co.

Packaged Boilers.....Sizes through 600 hp...oil, gas and combination oil-gas firing...larger sizes in Springfield water-tube boilers. Booklet, "How to Select a Boiler."
107 *Cleaver-Brooks Co.

Plate Heat Exchanger.....Case history brochure details actual processing applications while catalog describes models ranging from 500 to 500,000 lbs/hr. capacity.
14-15 *De Laval Separator Co.

Rotary Coolers.....Four types of rotary coolers are available, gas-cooled type, water-cooled shell, tubular type & direct-contact water. Information.
142 *Hardinge Co., Inc.

Steam Trap.....Model N-150 thermostatic steam trap features all steel construction wih just one working part. It is freeze-proof when installed vertically.
136 *W. H. Nicholson & Co.

Steam Traps.....have only two moving parts, the lever assembly & the bucket. The 44-page steam trap book discusses trap selection, installation and maintenance.
147 *Armstrong Machine Works

Tank Suction Heaters.....16-page bulletin 60-J1 covers design and operating characteristics for either intermitent or continuous removal of highly viscous fluids from tank storage.
157I Davis Engineering Div.

Instruments & Controls

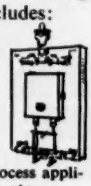
Computer.....Recoup III is the newest low-cost compact digital computer. Full information is available on its proven performance and quality.
16-17 *Autonetics Div. of N. American

* From advertisement, this issue

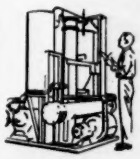
WILLIAM C. DIMAN,
Atmosphere Equipment Specialist, reports . . .

MODERN PROCESSES DEMAND MODERN ATMOSPHERES

Ever since 1927, when C. I. Hayes perfected the first controlled-atmosphere heat treating furnace, we have made a steady effort to further the technology of atmosphere generators and dryers. By recommending proper generators and dryers, we have helped our customers speed production, improve product uniformity and quality and save processing time and trouble. The big Hayes equipment line includes:



MOLECU-DRYER (using LINDE'S Molecular Sieves) — for drying, sweetening, purifying protective atmospheres and for gas and liquid separation and recovery. Exit gas dew points to less than minus 100°F. Many standard sizes available for process applications, instrument air drying, etc.



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NITROGEN GENERATORS (using LINDE'S Molecular Sieves) — produces 99.99% pure inert gas at about 20¢ per 1000 cu. ft. Standard sizes from 1000 CFH to 10,000 CFH.

"ENGINEERED ATMOSPHERES" — HAYES offers a broad range of equipment for producing oxidizing, reducing, carbon-potential, and nitrogen-hydrogen atmospheres . . . also engineered equipment packages for stand-by (start-ups, emergencies, etc.). Standard sizes are available in all types: Exothermic, Endothermic, and forming gas generators — also ammonia dissociators.

Hayes offers more than just equipment. Our Engineering organization and experimental lab. are ready to help make sure you get the right atmosphere equipment for your work.

ASK FOR BULLETINS . . .	Bulletin No.
Molecu-Dryer	5703-A
Nitrogen Generator	5901-NI
Exothermic Generator	256-A
Endothermic Generator	5808-A
Ammonia Dissociator	256-A
General Bulletin	256-A
Forming Gas Generator	5810-GC

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Established 1905
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It pays to see Hayes for metallurgical guidance, lab facilities, furnaces, atmos. generators, gas liquid dryers.

DEPENDABLE
VALVES for TIGHT SEALING
in those
TOUGH PROCESS APPLICATIONS

PENTON COATED DIAPHRAGM VALVE

This valve uses a rubber diaphragm to seal the fluid in valve body and a rubber covered disc to close the valve tight. Penton coating of body provides protection against corrosive action. Valve has high capacity—low pressure drop. Available in ½" to 6" sizes; manual or mechanical operators. Air diaphragm operated unit shown here. Write for Bulletin 800C.

ALL PLASTIC FULL FLOW VALVE

Valve with body in wide choice of plastics. Soft rubber or elastomer plunger seals off fluid flow. Full straight-thru design, with no obstructions or reduction in cross section area when full open, minimizes pressure loss. Sizes 1" to 2". Write for Bulletin 802D

W. S. ROCKWELL CO.
2300 ELIOT, FAIRFIELD, CONN.

LITERATURE . . .

Dial Indicator.....Six-inch dial indicator gives easy, accurate readings at point of measurement. Designed specifically for field indication. Specification S224-1.
12-13f *Minneapolis-Honeywell

Electric Transmitter.....Bellows flow meter can be used as an electric transmitter with indicators, recorders & conrollers. Specification FS 301-7 is offered.
12-13e *Minneapolis-Honeywell

Gauges.....Dial-type gauges show tank contents at-a-glance. Available to measure and indicate virtually any liquid at tank site or remotely. Literature.
138 *The Liquidometer Corp.

Impulse Modulation Controls.....Technical bulletin describes impulse modulation indicating temperature controls designed to produce proportional heat input/temperature balances.
158A The Parlow Corp.

Indicating Pneumatic Transmitter..... A Bellows flow meter may be used to give indication at the point of measurement plus pneumatic transmission. Specification S230-1.
12-13c *Minneapolis-Honeywell

Liquid Level Control.....is available for controlling level changes from ⅛" to 150 ft. Multi-stage switching when desired. Information on Magnetrol on request.
T154 *Magnetrol, Inc.

Liquid Level Transmitter.....New extended diaphragm liquid level transmitter has been designed especially for thick-wall tanks. Bulletin 13-22 is available.
113 *The Foxboro Company

Meter.....New meter with remote readout, especially designed for handling corrosive liquids, is described in bulletin that includes an accuracy graph and specifications.
158B Badger Meter Mfg. Co.

Meters.....Niagara meters to meet every liquid handling need. A wide choice of metering instruments and components. Further information is available.
123 *Buffalo Meter Co.

Non-Indicating Transmitter.....for use when you don't need indication at the point of measurement. A copy of Specification S230-1 is available on request.
12-13d *Minneapolis-Honeywell

Processing Control Systems.....Detailed information on Lintorque process control systems is contained in Bulletin 6-57 which is available on request.
28 *Philadelphia Gear Corp.

Recorder & Integrator.....The Bellows flow meter may be used as a recorder or integrator. Specification S292-2a is available on request for details.
12-13a *Minneapolis-Honeywell

Recording Controller.....Specification S292-2a is available to show how to use the Bellows flow meter as a recording controller with pneumatic On-Off.
12-13b *Minneapolis-Honeywell

Thermometers.....New liquid-filled dial indicating thermometers are low-priced. Dials are big, legible & raised to reduce parallax reading error.
26 *Autolite

Pipe, Fittings & Valves

Globe Valves.....feature less corrosion attack because of elimination of cavity between stem and disc. Full information is to be found in Bulletin #7 which is available.
131 *Alloy Steel Products Co.

Needle Valves.....Three great series, alloy steel, stainless steel and 416 stainless steel are available. In a full range of sizes and patterns including panel mounted.
B154 *Marsh Instrument Co.

Pinch Valves.....to control lime slurry. The soft rubber sleeve of the valve resists the abrasive and corrosive action of the lime.
L140 *Red Jacket Co., Inc.

Pipe & Tubing Measurement.....Booklet supplies standard methods of measurements and discusses both similarities and differences involved in measuring various fittings.
158C Aeroquip Corp.

Semi-Steel Valves.....Specifications and dimensions are given in catalog for all sizes of semi-steel straightway, steam jacketed, multiport and special order valves.
158D Rockwell Mfg. Co.

Tubes.....U-bend tubes offer higher efficiency and greater economy. Information is offered on duplex tubes, dual-gage tubes as well as U-bend tubes.
75 *Anaconda American Brass Co.

Tubing.....Penflex tubing moves anything from gases to granules. It expands, contracts and absorbs vibration. A new catalog and data book is available.
148 *Penna. Flexible Tubing Co.

Tubing.....Excelon tubing nationally distributed for industrial and laboratory uses and whenever flexibility, clarity and chemical inertness is required.
TR160 *Thermoplastic Processes, Inc.

Tubing, Welded Steel.....Prevent corrosion when the pressure's on with welded stainless steel tubing. Available in Schedules 40S, 10S & 5S. Booklet 8591.
111 *Welded Steel Tube Institute

Valve.....The Penton coated diaphragm valve is available in ½" to 6" sizes; manual or mechanical operators. Additional information in Bulletin 800C.
158a *W. S. Rockwell Co.

Valve.....with body in wide choice of plastics. Soft rubber or elastomer plunger seals off fluid flow. Sizes 1" to 2". Bulletin 802D available.
158b *W. S. Rockwell Co.

Valve Catalog.....132-page catalog covers complete line of stainless steel valves and accessories. Includes ball, gate, globe, check angle, "Y", sampling, tank and needle valves.
158E Cooper Alloy Corp.

Valves.....Forged steel ASA class valves for 400 deg. F. maximum working temperatures plus ASA class valves for 450 deg. F. maximum. Prices available.
169 *Orbit Valve Company

* From advertisement, this issue

Valves.....Corrosion-Resistant valves are available in a wide selection of materials, to handle practically every known corrosive media. Details on request.
105 *The Wm. Powell Co.

Valves, Baffles, Traps.....28-page brochure details specifications, descriptions and methods of operation with illustrations and drawings of high-vacuum equipment.
159A Consolidated Vacuum Corp.

Valves, Diaphragm.....resist attack by hot corrosives. The diaphragm lifts high for streamline flow-seals tight for positive closure. Further information.
59 *Grinnell Company

Valves, Solenoid.....The valves covered in Catalog Manual 108 have a plastic body and diaphragm. Contains a chemical selection list & valve selection chart.
159B Valcor Engineering Corp.

Venturi Valves.....Pamphlet describes valves and includes chart that embodies experimentally determined discharge coefficients and diffuser recovery efficiencies of valve.
159C Fox Valve Development Co. Inc.

Weld Couplets.....are easy-to-install fittings for branch connections from pipes, vessels or tanks. Information is contained in Folder SWC-1 which is available.
76 *Henry Vogt Machine Co.

Process Equipment

Blender.....Liquid-solids blender granulates tablet formulations in a single step. A new report on solid-lending and Catalog 16-P on process equipment is available.
8-9 *Patterson-Kelly

Dissolver....For use with any product requiring mixing, dissolving, dispersing, emulsifying or deagglomerating. Further details are available on request.
27 *Morehouse-Cowles, Inc.

Dryer.....keeps instrument and tool air desert dry. Case history sheets illustrate in details specifications & solutions to a multitude of moisture problems.
146 *Pittsburgh Lecrodryer Div.

Dryer, Rotary Hot Air.....is made from stainless steel. Catalog A contains information on these dryers and other dryers & coolers and is available on request.
T155 *Davenport Machine & Fdry.

Exhaust Purifier.....4-page booklet features eleven problem solution case histories of typical exhaust purifier installations on various industrial vehicles.
159D Oxy-Catalyst, Inc.

Feeding Systems.....Continuous feeding/blending saves material; reduces costs, controls quality & results in bigger processing profits. Facts booklet offered.
R144 *B-I-F Industries

Filter.....EimcoBelt continues belt filters successfully handle slurries that have always been considered impossible for vacuum filtration. Bulletin FE-2053 is offered.
Cover *Eimco Corp.

Filter Aids.....Bulletin B-14 discusses the principles and operating practices of filteraid filtration and its applications in many industries. Available on request.
4 *Great Lakes Carbon Corp.

Generator.....Nitro-Gen generator can produce gases of oxidizing & reducing characteristics by varying gas/air ratio. Further details are available in Bul. 5901-N1.
157b *C. I. Hayes, Inc.

IMP Mill.....Catalog 87E shows the many applications of this multi-purpose grinding unit such as grinding, blending, separating, conveying, & drying.
74 *Combustion Engineering, Inc.

In-Line Blending System.....mixes fluids right in a pipelyine. Eliminate batch mixing, holding tanks, and give great accuracy. Many types of systems are available.
99 *Fischer & Porter Co.

Liquids-Solids Separation.....Eight types of centrifugals and filters to separate solids from liquids. Research & Development Center for pilot-scale testing.
2 *Bird Machine Company

Mill.....Pulver-Mill does in one step what used to take two. Designed for fine grinding and precise end product classification. Send for Bulletin 093.
R140 *Sturtevant Mill Co.

Process Equipment.....for any process requirement. A new brochure, "From Arc to Atom" has been prepared giving details and is available on request.
137 *A. O. Smith Corp.

Support Plates.....Bulletin TA-40 gives full technical data on "gas-injection" support plates plus a line of distributors & hold-down plates. Send for your copy.
32 *U. S. Stoneware

Thickeners & Clarifiers.....for all water treatment, countercurrent washing & thickening & clarification operations. Bulletin T5-B6 is available on request.
130a *Denver Equipment Co.

Pumps, Fans & Compressors

Blower.....RAS blowers are gas tight, even for hot or light gases. They are compact, completely enclosed. Details of their advantages are available on request.
119 *Roots-Connersville Blower

Compressor, Piston.....assures absolute contamination-free compression of dry or moist gases. Unique ringless piston & frictionless piston rod. Information & specifications.
133 *Sulzer Bros., Inc.

Compressors.....H-line compressors include a wide variety of sizes and capacities, from 300 to 40,000 icfm. Specific information is available on request.
57-58 *Elliott Company

Compressors.....Complete information on all types of high pressure, air and gas compressors is contained in a descriptive catalog which is available on request.
143 *Norwalk Co., Inc.

* From advertisement, this issue

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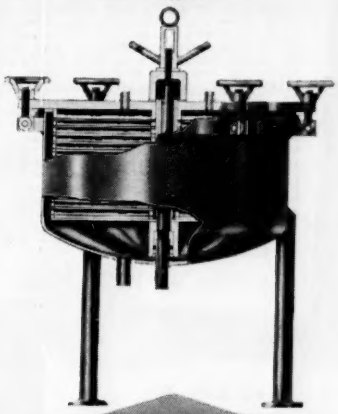

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LITERATURE . . .

Pump, Slurry.....Type JC slurry pump is standardized for simplified maintenance. Bulletin 191 contains detailed information and is available on request.
61 *Morris Machine Works

Pump, Vacuum.....The new Series H Microvac pump is designed for compactness. Information about this type plus a Vacuum Slide Calculator are offered.
156 *F. J. Stokes Corp.

Pumps.....Durcopumps are available in fourteen alloys and special materials. Heads to 345 feet, capacities to 3500 gmp. Further information in Bul. P-4-100.
109 *The Diriron Co., Inc.

Pumps, Diaphragm.....Stroke can be adjusted while pump is operating. Sizes 1" to 10" simplex and duplex, capacity to 1000 gpm. Bulletin P8-B12 offered.
130b *Denver Equipment Co.

Services & Miscellaneous

Acidity Determination.....Data sheet outlines method for determining acidity where slight changes in acid concentration cause only slight changes in indicator color.
160A Technicon Controls, Inc.

Concrete Floor Maintenance.....8-page pamphlet gives step-by-step procedures for curing, sealing and continued maintenance of both new and old concrete floors.
160B Puritan Chemical Co.

Equipment Leasing.....Brochure presents facts on the leasing of new and used equipment and explains how any type or amount of equipment can be obtained on lease.
160C U. S. Leasing Corp.

Film Guide.....1961 catalog lists 223 films and includes alphabetical and subject indexes. Subjects range from Home Economics to Laboratories. Research & Production.
160D Manufacturing Chemists' Assoc.

Floodlights.....A 16-page color brochure, "Area Floodlighting Made Easy" gives quick reference guides for selecting incandescent or mercury floodlights. Bulletin 2719.
160E Crouse-Hinds Co.

Gratings & Assemblies.....Safety handbook and design manual features gratings for industrial purposes such as outdoor conveyor ramps, stair treads, floors, etc.
160F Bustin Steel Products Inc.

Laboratory Furniture.....A new 40-page catalog provides a quick reference implement for basic planning of laboratory & hospital installations. Available on request.
L144 *S. Blickman, Inc.

Ultrasonic Cleaning.....14-page booklet "Chemicals for Ultrasonic Cleaning" gives information on physical properties of most commonly used cleaning chemicals.
160G Branson Instruments Inc.

Vacuum Products Catalog.....16-page catalog contains technical descriptions of pumps in sizes from 0.2 liter/sec. to 10,000 liter/sec. plus other high vacuum products.
160H Varian Assoc.

* From advertisement, this issue

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436 Allis Chal Hydrocone 75 H.P. Motor
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1—550 sq. ft. Buflovak monel single effect Evaporator.
1—500 gal. S.S. Mixing Tank, nickel coils.
6—7500, 6000 and 2000 gal. Rubber Lined Tanks.
1—1500 gal. Stainless Pressure Tank, 5' x 10', 90#.
1—2,000 gal. horiz. 304 S.S. tank, 5' x 12'.
1—2500 gal. vertical 304 S.S. Tank, 8' x 7'.
1—10,000 gal. rubber lined Tank 10' x 17'6".
2—2700 gal. 316 SS Vertical Agitated Tanks with Coils.
1—4200 gal. 316 SS Vertical Tank, 8' x 12'.
1—5500 gal. 316 SS Clad Pressure Tank, 250 psi.
1—12,000 gal. horiz. steel Pressure Tank, 7'6" x 36', 200 psi.
4—Stainless Heat Exchangers; 536, 370, 315, 250 sq. ft.
1—24" dia. x 35', 304 S.S. Bubble Cap Col.

FILTERS

1—#5 Sweetland Filter 304 S.S. 120 sq. ft.
1—Oliver 6' dia. Horizontal Filter, 316 S.S.
1—Oliver 4' dia. Monel Horizontal Filter.
1—Oliver 5' x 6' Steel Rotary Vacuum Precoat Filter.
1—U.S. 200 sq. ft. 304 S.S. Auto-Jet Filter.
1—Hercules 400 sq. ft. 304 S.S. Pressure Filter.
1—Oliver 5'3" x 8' Steel Rotary Vacuum, vaportite housing.
1—Feinc 3' x 1' 316 SS Rotary Vacuum Filter.
1—Feinc 5' x 6' Stainless Steel Rotary Vacuum Filter.
2—#12 Sweetland Filters, 36 leaves, 4" centers, 500 sq. ft.
2—#10 Sweetland Filters, 27 leaves, 4" centers, 250 sq. ft.

DRYERS

1—Buflovak Vacuum Shelf with 17—60" x 80" shelves.
2—Buflovak 42" x 120", atmospheric double drum Dryers, complete.
1—Buflovak 32" x 90" Atmos. Twin Drum.
2—Devine 4' x 9' single drum, atmospheric.
1—Buflovak 3' x 10' Rotary Vacuum Dryer.
1—Stokes 4' x 20', 304 SS Rotary Vacuum.
6—Louisville Rotary Steam Tube 5' x 25', 6' x 30', 6' x 50'.
2—Louisville 8' x 50' Stainless Steel lined Rotary Dryers.
9—Rotary Dryers 34" x 30', 4' x 40', 6' x 50', 6' x 60', 7' x 80', 8' x 87'.
1—Louisville 4½' x 25' Inconel Rotary.
2—Link Belt, 7'5" x 25', 6'4" x 24", S.S. Louvre Dryers.
1—Stokes model 38-A Tray Dryer with 16—36" x 36" S.S. Shelves.
2—Atmos. Tray Dryers, 16 shelves, 40" x 24".
1—P&S 6' wide Apron Conveyor Dryer 48' long.
2—10' and 4' dia. 304 S.S. Spray Dryers.
2—Wyssmont Dryers, 304 S.S. 6'2" and 9'6" dia.

MIXERS

1—Abbe 110 gal. 304 S.S. Jacketed Agitated Vacuum Dispersall Mixer.
2—Day Imperial 150 gal. jktd. double arm.
2—Baker Perkins 150 and 100 gal. jacketed double arm Sigma blades.
1—Baker Perkins 50 gal. jacketed, double-arm.
5—Day "Cincinnatus" double arm, 250 and 100 gal.
2—Steel jacketed Powder Mixers, 225 and 350 cu. ft.
1—Patterson 6' dia. Conical Blender 15 HP.
1—3' dia. Simpson Intensive Mixer.
1—2' dia. Simpson Intensive Mixer 304 S.S.
1—45' dia. Lancaster Mixer 7½ Hp motor.
1—Patterson Kelly 150 cu. ft. Twin Shell Blender.
1—Patterson 80 cu. ft. Conical Blender, 304 SS.

MISCELLANEOUS

3—Kinney Vacuum Pumps, 1000 cfm, 10 microns, 15 HP.
1—Thropp 6' x 12" 2 Roll Mill, 7½ HP motor.
2—Hardinge 5' x 22" steel lined conical Ball Mills.
3—Mikro Pulverizers, 1SH, 1SI and Bantam.
3—Abbe 2½" x 3' porcelain lined Pebble Mill XP motor.
1—Raymond 10" vert. Mill, 10 HP.
1—No. 1 Ball & Jewell Rotary Cutter.
1—#18 Cumberland Rotary Cutter.
3—Swenson Walker Continuous Crystallizers, 24" x 30' sections.
2—#842 Rotex Sifters 60" x 84" double deck.
1—#24 Rotex Sifter, 20" x 64", Quadruple deck.
5—Day Roball Sifters, 40" x 120", 40" x 84", Double Deck.
3—Nash H6 Vacuum Pumps.
4—Stokes Rotary Tablet Machines DD2-DD52-DS3-RB2.

Partial List of Values—Send for Complete Circular

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NEW FILTER, stainless steel NIAGARA 48" dia. w/510 sq. ft.

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FURNACE, electric, 5"X12"X30" muffle, 1600°C, Globar, w/50KVA transformer

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Davenport Model 3-A cont. Dewatering Press. Cap 2600# per hour

Kemp Inert Gas Producer. 6000 CFH Model 6-MIHE. New 1958. Used 6 mon.

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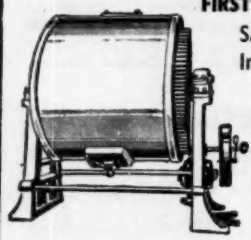

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3000 Gal. Nickel Clad Reactor 7' x 11', Jacketed and Agitated
Cornell Stainless Model C-D26 Versators

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Stainless Centrifugals from 30" to 60"; A.T.&M. Tolhurst, Fletcher, etc.
Tolhurst 40" Suspended Centrifuges; Rubber Covered Perf. Baskets and Curbs; Monel Plow-Discharge.
2 Sharples Stainless Steel Model PN14 Super-D-Canters.
4311 S 1 Sharples C 27 Super-D-Hydrator in Type 316 Stainless with 40 HP
5147 S 13-14 Two Bird Continuous Screen Type Horizontal Centrifuges; Monel & S.S.; 24" x 24".
2 Bird Rubber Covered, 48" with Plows; Fume Tight; 40 HP.

ROTARY VACUUM FILTERS

3" x 2" Monel. 5'3" x 8' Stainless.
(2) 5'3" x 3" Steel or Rubber.
Feinc S/S Rot. Vac. Filter 3' x 1'.
Oliver Cont. Rot. Vacuum Filters.
Panel Type; 8' x 8' and 8' x 10'.

REACTORS—PRESSURE VESSELS

2 Stainless 400 gal. Reactors Jktd. Agtd. by Patterson and Struthers.
6 Dorr-Oliver Stainless Steel Thickeners or Reaction Vessels; 550 gal. 5' x 5'.
Stainless Reactor, 2000 gal. Fully Jktd. Agitated.
Nickel Clad Reactor, 7' x 11'6".
Lancaster Stainless Lined Rotary Reactor or Digester; 50" x 17'4"; Jacketed; good for 300 PSI Internal.
Pfaudler Gl. Lined Reactors; all sizes from 50 to 500 gal.
Mojonnier Stainless Vac. Pans; 3' x 10' and 6' x 12'; others.

MILLS—PULVERIZERS

2 Stainless Steel Micronizers 30".
Abbe, Ball & Jewell Rotary Cutters; in a wide range of sizes, capacities.
Ball Mills and Pebble Mills by Abbe, Patterson, International, some Jacketed; up to 8' x 8'.
Mikro Pulverizers up to No. 4's.
Fitzpatrick Comminutators; Models M, K and C; motorized.
American Ring Roll Crusher; 50 HP.
Mikro S/S Atomizers; Nos. 6 and 5.
Raymond Imp Mills; many sizes.
Williams Hammer Mills to 60 HP.
Double Drum Dryers to 40" x 120".
Devine Double Door Vacuum Chamber Dryers; Model No. 36.

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2 Allis Chalmers 7' x 22' (2 Compartment) Compeb Mills, Meehanite Liners; 400 HP
1 Allis Chalmers 9½ x 810 Preliminator or Continuous Ball Mill; Meehanite Liner magnetic-coupled to 400 HP Motor
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2—96" dia. x 22 plate steel beer-still columns, 44' high.
5—Buflovak 42" x 120" dbl. drum dryers, ASME 160#
2—Amer. 36" x 84" dbl. drum dryers
2—Bonnet 7' x 60' rotary dryers, 5/8" shell, with burners, fans, etc.
9—Davenport #1A #2A dewatering presses, vari-drives
2—French Oil type 2-S screw-type extraction presses 300 PSI, 60 HP.
2—Sweetland #12 pressure filters
6—Shriver 48" Cast Iron P. & F. filter presses, (50) chambers
2—19,900 sq. ft. quadruple effect calandria type evaporators
6—691 sq. ft. dbl. pipe coolers
3—American 654 sq. ft. spiral steel heat exchangers
18—Tubular heat exchangers, copper tubes: 1500, 1350, 1130, 637, 380, 290, 184, 176, 156 sq. ft.
2—9500 gal. horiz. cookers, 9' dia. x 20' long, ½" shell & heads.
2—Warren 12" x 12" cent. pumps
250—Steel centrifugal pumps, 1" to 12", 1 HP to 150 HP
2—Aldrich triplex pumps, 162 GPM @ 175# WP.
3—1000 KVA trans., 13800—460 v.

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72—Pfaudler 1400 gal., blue G/L jkt. kettles, Agit.

18—Pfaudler 1250 gal., Blue G/L jkt. reactors, closed, Agit.

54—Pfaudler 600 gal., Stainless Steel jkt. open kettles.

72—Pfaudler 250 gal., blue G/L jkt. kettles.

18—Pfaudler 11,500 gal. horiz. blue G/L tanks, 20# WP, nickel coils.

60—1350 gal. T347SS tanks, 4' x 14', ASME 60# WP, coils.

9—13,300 gal. T321SS vert. tanks, 12' x 15'.

3—Edgemoor Iron 3000 CFM waste-heat boilers.

16—Duriron packed-type columns, 24" x 15' high.

3—Worthington 24 x 15 air compressors, 3500 CFM, with 500 HP, 4-cylinder gas engine drive.

8—Elliott Turbo-blowers, type #0, 11,620 CFM, 15.9# abs. disch., 125 HP.

3—Alloy-Fab. 564 sq. ft. Stainless Steel gas "burner-preheater" exchangers.

30—27,500 gal. horiz. Steel tanks, 11' x 38', ASME 75# WP.

72—475 gal. open Stainless tanks.

18—3250 gal. vert. Stainless tanks.

KETTLES—REACTORS

1—1800 gal. T316SS reactor, vacuum internal, new jacket.

4—1350 gal. T347SS Kettles, open top, paddle agitators.

1—1000 gal. Dopp cast iron Kettle, 125# jacket, 15# int., 25 HP TEFC Agit.

1—750 gal. Graver T304SS jkt. fermenter, ASME 30# int., 30# jkt., 10 HP Turbine Agit.

1—600 gal. Bartlett & Snow SS evap. & crystallizing jkt. Kettle.

1—600 gal. T304SS reactors, Jkt., Agit.

2—500 gal. T304SS reactors, jacketed, ASME, Vacuum—Unused.

6—465 gal. T304LSS reactors, jacketed, 150# int., 175# Jkt.

2—400 gal. Glascote blue G/L reactors, Agit., Jkt., ASME.

1—300 gal. Pfaudler blue G/L reactor, Agit., Jkt., ASME.

1—300 gal. Glascote blue G/L reactor,

1—200 gal., T304SS, vac. int., 200# WP Jkt., Agit.

MIXERS — MILLS

40—Baker-Perkins #17, 200 gal. sigma-blade, jkt. mixers.

1—Baker Perkins #16-UUEM, 150 gal. Disp.-blade, jkt., 150 Hp, vaulted cover, motorized tilt.

1—Baker-Perkins #15, 100 gal. Disp., T347SS.

1—Baker-Perkins #15-UUMM, 100 gal., Disp. blade, ASME jkt., 100 HP, Comp. Cover, motorized tilt.

1—J. H. Day #6, 100 gal., St. St. sigma

2—J. H. Day #5, 75 gal., sigma.

1—J. H. Day #2, 20 gal., sigma, jkt.

1—Raymond 66", 6-roller mill, 200 HP.

1—Raymond 50", 5-roller hi-side mill.

1—Allis-Chalmers 5' x 5' ball mill.

13—Abbe 6' x 8' batch pebble mills.

2—Hardinge 7' x 36" conical mills.

1—Babcock & Wilcox #E-32 mill, 75 HP.

EVAP. — STILLS COLUMNS — CONDENSERS

7—4050 sq. ft. calandria type evap., copper tubes, cast iron shell

1—Mojonnier 2085 sq. ft. triple-effect Stainless Sanitary evaporator.

4—Buflovak double-effect stainless evap. vert. long-tube type: 1025, 840, 710, 588 sq. ft.

1—Stokes 118 sq. ft. T316SS Still.

1—Bartlett & Snow 6' dia. Stainless jkt. evap.- crystallizing kettle.

1—Vulcan 110" dia. x 16' high T316SS bubble-cap column, 10 trays.

1—Vulcan 60" dia. x 16' high, T316SS bubble-cap column, 10 trays

1—Vulcan 60" dia. x 42' high T316SS bubble-cap column, 35 trays.

1—36" dia. x 9'-8" T316SS bubble col.

15—Copper bubble-cap columns, 24" to 54" dia., to 51' high.

1—1960 sq. ft. T316SS exchanger, remov. bundle, ASME 75# WP.

1—1450 sq. ft. T316SS condenser.

5—1400 sq. ft. T316SS gas converters.

3—800 sq. ft. T316SS condensers.

1—730 sq. ft. T316SS exchanger.

1—510 sq. ft. T316SS condenser.

30—T316SS condensers & exchangers: 427, 425, 410, 400, 290, 277, 264, 250, 200, 185, 165, 150, 145, 105, 83, 73, 54, 52, 50, 47, 30 sq. ft.

12—185 sq. ft. T304SS U-tube coolers.

FILTERS—CENTRIFUGALS

6—Shriver 48" C.I. P&F filter presses, 1000 sq. ft., closed delivery

6—Valley 36" aluminum P&F filter presses, 65 ch., closed delivery.

5—Sweetland #12 filters, (72) stainless leaves, open deliv.

2—Sweetland #7 filters, 239 sq. ft.

1—Niagara #510-28, T316SS filter.

1—Oliver 5'3"x8' recoat rotary vacuum filter, UNUSED.

2—Oliver 5'3"x3' precoat rot. vac. filter, T316SS, ASME 30# WP.

1—48" Tolhurst susp. cent., T304SS.

5—40" A.T.&M. susp. cent., T304SS.

2—32" A.T.&M. susp. cent., T304SS.

1—12" A.T.&M. susp cent., T304SS.

28—Sharples #AS-16V super cent., Inconel, vapor-tite, sludge-disch. frame.

2—Sharples #16-P super cent., T304SS, pressure-tite.

2—Sharples #C-20 Super-D-Hydrators.

2—Bird 24" x 38" cylin. T304SS.

1—Bird 24" x 38" cylin. Steel

3—Bird 24" x 24" Slotted, Monel

DRYERS—KILNS

5—Buflovak 42" x 120" double drum dryers, ASME 160# WP.

1—American 42" x 120" dbl. drum, ASME, St. St. Acc.

1—Buflovak 42" x 90" Dbl. drum.

1—Buflovak 32" x 72" twin drum dryer, chrome plated drums, St. St. trim.

2—American 36" x 84" Dbl. Drum

1—Buflovak 32" x 52" dbl. drum.

1—American 36" x 84" double drum dryer, ASME, VACUUM.

1—Buflovak 5' x 12', single drum dryer, Vacuum UNUSED.

1—Buflovak 6" x 8" dbl. drum.

5—F. J. Stokes #138J-16, 195 sq. ft. vac. shelf dryers.

1—Buflovak 110 sq. ft. vac. shelf

1—Turbulaire Stainless spray dryer.

1—Nerco-Niro stainless spray dryer.

1—Vulcan 10' x 11' x 175' rotary kiln.

2—10' x 78' rot. dryers, ¾".

2—Hardinge 8'-8" x 70" rotary, ⅜".

1—Traylor 8' x 80' rotary, ⅜".

2—Davenport 8' x 60' rotary, 7/16" welded burners, fans, etc.

2—8' x 56' rot. kilns, ½" welded.

1—7'-6" x 62' rotary kiln, ½".

2—Bonnot 7' x 60' rotary, ⅜".

1—Louisville 4'-6" x 25' steam-tube.

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HYDRAULIC PRESS MFG. CO., Hydraulic Steeping Press, 118 Ton Horizontal Acting with Hydraulic Operated End Gate, main dia. 11/10", Pressing Surface 55" x 20", Stock Space 128⅝" platen to end gate 151⅞", max. travel 168", Ram Speeds: Closing 27"/min., Pressing 12"/min., Opening 70"/min., 43 Division Plates, 200 Gal., Oil, Hydraulic System Tape OVHA-22, Pressure Design 2485 PSI. 5 HP 3/60 220-440 NEW 1952

ZANTHATORS

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6—BAKER-PERKINS Dissolver — Size 2-E (large), 20 HP, M/D

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34—SHRIVER Filter Press, size 30, 100 lb. Filter Pressure, ⅞" Thick Plate, 252 Square Feet, 358 gallons per hour
40—SHRIVER Filter Press, size 12"

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Complete Sodium Sulphate Plant, 20 Tons Per Day

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Large Quantity Stainless Steel, Stainless Steel Sprayed on Copper, Lead lined, Rubber lined and Steel

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Large Quantity M/D Pumps, Stainless Steel, Lead, Bronze, Rubber lined, Carbate, Steel

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1—INGERSOLL-RAND Air Compressor, 125 HP, M/D, NEW 1952
1—PENNSYLVANIA Pump and Compressor Co. Air Compressor Size 12 x 18 x 5, 60 HP, M/D
1—INGERSOLL-RAND Air Compressor, Type XRB, 60 HP, M/D
1—YORK Ammonia Vertical Compressor. M/D, 40 Ton to 87 Ton Capacity
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CARRIER Centrifugal Refrigeration Machine, 800 Ton Model 17-M63-9-5/3-3-9/2, Using Carrene #2, F-11 To Cool 1900 GPM of Water. From 50° F to 40° F. When supplied with not less than 2370 Gal. of Condensing Water @ 85°F., with Cooler and Condenser, Steam Turbine, Recording Controller, Precisor, NEW 1952
CARRIER Refrigeration Machine, Freon, 285 Tons, with 300 HP, M/D, NEW 1950
CARRIER Refrigeration Machine, Freon, 415 Tons, 400 HP, M/D, NEW 1952
CARRIER Refrigeration Machine, Freon, 350 HP, M/D, NEW 1950
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CARRIER Freon Compressor, 40 HP, M/D

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SILENTVANE Fan, Design 10, Sturtevant Size #85
3—72" CLARAGE Fan Blower, 75 HP, M/D
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B&P 300 gal. 18DIM Sigma Blade Mixer
Dopp 1000; 1700 gal. Reactors jkt., agit.
435 Sq. ft. Single Effect Evaporator
Goslin Birm. 36"x24" Rotary Vac. Filter
Sharples C27 Super-D-Hydrator
3'x18" Crystallizer, jkt., agitated.
Swenson 24"x20' jacketed Crystallizers
Brown Fintube Exchanger, 618 sq. ft.
Triplex 2¼"x4" Pumps 18 GPM @ 2000 PSI
Centrifugal Pumps 1", 1½" & 2"

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78"x18' Bubblecap 14 tray, 50 PSI
72"x30' Bubblecap 21 tray
54"x30' Bubblecap 26 tray, 100 PSI
48"x41' Bubblecap 40 tray, 100 PSI
36"x20' Packed, 100 PSI
30"x22' Packed, 75 PSI
14"x18' Packed, 10 PSI
12"x18' Packed, 100 PSI

S.S. TANKS

4500 gal. 6'x25' dish/cone heads, 25 PSI
4000 gal. 8x12' dished heads, coiled
4000 gal. 5'6"x24'6" dish/cone/heads coiled
4000 gal. 7'6"x14' dished heads
3500 gal. 8'x9' dished heads
1500 gal. 6'x6'9" dished heads
750 gal. 5'x5' plain and agitated
500 gal. 4'x5' plain and agitated
400 gal. 4'x4' plain and agitated
300, 250, 150, & 100 gal.

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Pfaudler 500 gal. ELL Glass Lined Reactor
Buflovak Vacuum drum Dryer 6"x8" drums
Buflovak 6' Vacuum Crystallizers
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Copper Tanks 3500 gal. to 200 gal.
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Chlorimet #3 Centrifugal Pumps. New
Sweco 48" Separator 3 SS Screens

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CIRCLE U ON READER SERVICE CARD

ALCOHOL AND ETHER PLANT

Must Move at Once from Present Location

2 Vulcan Bubble Cap Columns 78" x 39'—14 Tray—Copper Cap. 266,000 lbs. for 24 hrs.
2 Vulcan Continuous Ether Columns 54" x 30' — 436,000 lbs. per 24 hrs.
Condensers—Coolers—Vents

NITRIC ACID CONCENTRATION PLANT

3—14,000 Gal. Lead Lined Tanks
4—4700 Gal. Lead Lined Tanks

STEAM DRIVEN AIR COMPRESSOR

1138 CFM Ch. Pneu. Built 1945

HARRIS MACHINERY COMPANY

501 30th Ave. S.E.—FE. 1-1829
Mpls. 14, Minn.

CIRCLE V ON READER SERVICE CARD

Ion Exchange Plant For Sale.

Complete Fully Automatic Ion Exchange Plant, capable of treating 80,000 gallons per day containing 3.75 grams per litre U_3O_8. Surplus due to completion of government contract. Used two years, condition excellent. Any offer considered.

RAYROCK MINES LIMITED
Discovery, N.W.T. Canada

CIRCLE W ON READER SERVICE CARD

PIE in the sky? *NO!* Just the extra value in

GELB

CHEMICAL PROCESS EQUIPMENT

1—Gemco type 316 SS jacketed conical rotary vacuum blender, 92 cu. ft.
1—Struthers Wells SS 1150 sq. ft. single effect evaporator.
1—Oliver SS rotary vacuum filter, 3' x 2'
1—Sperry 36" x 36" heresite covered filter press, 40 chambers.

AUTO. KETTLES, REACTORS

2—Pfaudler Series R 5000 gal. glass lined jacketed reactors, NEW
1—Pfaudler Series 750 gal. glass lined reactor, jacketed
2—Pfaudler Series EM 300 gal. glass lined jacketed reactors
1—Pfaudler Series P, 30 gal. glass lined jacketed reactor, complete with agitator and drive
1—Pfaudler Series P, 20 gal. glass lined jacketed reactor with agitator and drive
2—Theo. Walters, Hastelloy B, 300 gal. jacketed reactors
2—Blaw Knox 200 gal. jacketed autoclave, nickel, 175 psi jacket and internal
1—Blaw Knox 300 gal. stainless steel vacuum reactor
2—Blaw Knox steel autoclaves, 600 gals.
1—Alloy Fabricators steel jacketed autoclave, 600 gals.
1—Van Alst 300 gal. stainless steel jacketed kettle
2—Process Equipment 10,000 gal. SS vertical tanks, NEW

DRYERS

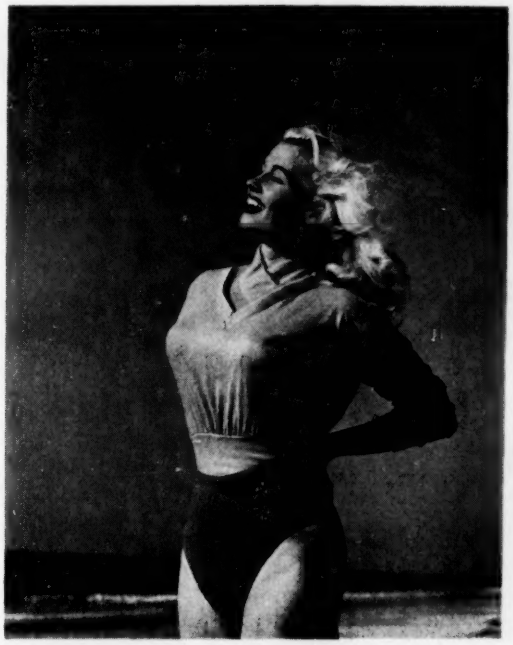
2—Bonnot rotary kilns, 8' x 115', complete
1—Bonnot rotary cooler, 8' x 50', complete
1—Allis Chalmers stainless steel rotary dryer, 6' x 50'
10—Allis Chalmers rotary dryers, 6' x 50' and 7' x 60'
1—Buflovak SS jacketed rotary vacuum dryer, 5' x 30'
1—Link Belt steel roto louver dryer, Model 207-10
2—Stokes SS jacketed rotary vacuum dryers, 3' x 15' and 2' x 6'
1—American 42" x 120" double drum dryer, ASME, complete
1—Buflovak steel jacketed rotary dryer, 3' x 15'
2—Stainless steel pilot plant spray dryers
1—Stokes single door vacuum shelf dryer, 6 shelves

CENTRIFUGES

1—AT&M 48" SS suspended type centrifuge, complete
1—Fletcher 48" SS underdriven centrifuge, complete
1—AT&M 26" type 316 SS suspended type centrifuge, complete
5—Tolhurst 40" and 30" rubber covered centrifuges
1—Sharples type 316 SS Super-D-Canter, PN-14, complete
1—Sharples type 316 SS centrifuge, Model D-2

FILTERS

1—Niagara stainless steel filter, Model 510-28
1—Oliver stainless steel rotary vacuum filter, 3' x 4'
1—Shriver plate and frame filter press, aluminum, 30" x 30", 30 chambers
10—Shriver plate and frame filter presses, 12" to 42"



THE GELB GIRL—MAY 1961

MIXERS

1—Banbury #1 mixer with 30 HP motor
1—Sturtevant #7 SS dustite rotary batch blender, NEW
15—Robinson type 304 SS horizontal blenders, 255 cu. ft.
1—Robinson type 304 SS horizontal blender, 125 cu. ft.
1—Baker Perkins Size 16 Type UUEM, 150 gal. jacketed double arm, dispersion type mixer, complete with compression cover and 100 HP motor
1—J. H. Day 5 gal. double arm sigma blade mixer, SS
1—Stokes stainless steel granulating mixer, Model 21-J

MISCELLANEOUS

1—Cleaver Brooks 500 HP package steam generator, 200#
1—Cleaver Brooks 150 HP package steam generator, 150 psi
1—Superior 300 HP package steam generator, 125 psi
1—Sprout Waldron pelletizer, Type 501 FF
1—Williams "Comet" 4 roll mill, complete
1—Raymond 2 roll high side mill
1—Ross 6" x 14" 3 roll paint mill, high speed, complete
1—Griscom Russell SS heat exchanger, 900 sq. ft.
1—Downington SS heat exchanger, 750 sq. ft.
3—Badger SS heat exchangers, 500 sq. ft. and 600 sq. ft.
4—Patterson SS condensers, 200 and 300 sq. ft.
20—Davis Engineering SS heat exchangers 102, 119, 136, 166 sq. ft., NEW
2—Davis Engineering Carpenter 20 heat exchangers, 120 sq. ft.
2—Mikro Bantam pulverizers
2—Mikro #3TH SS pulverizers, complete
3—Pfaudler glass lined thimble type condensers, 14 and 9 sq. ft.

1—Vulcan SS bubble cap column, 4' dia. x 25 plates
1—Hercules SS filter with 6 leaves
1—Sharples C-20 Super-D-Hydrator, monel
12—Sweetland #12 pressure leaf filters with 72 SS leaves

R. GELB & SONS, INC. 75 ANNIVERSARY
U. S. HIGHWAY 22, UNION, N. J. · MURDOCK 6-4900

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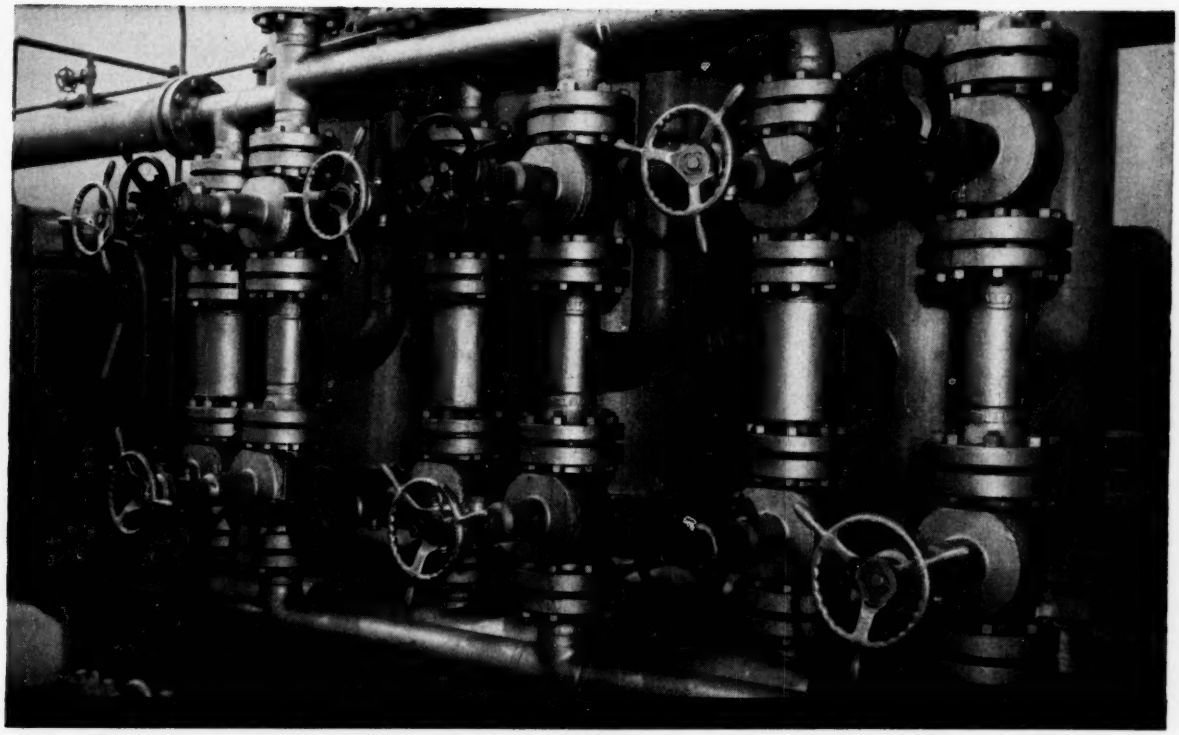

ORBIT VALVES ARE IMPORTANT PART OF EFFICIENT DEHYDRATION UNIT

HYDROCARBONS, AMMONIA, CARBON DIOXIDE, ETHYLENE, HELIUM, HYDROGEN, NITROGEN, NATURAL GAS — ALL REQUIRE DRYING UNDER CERTAIN CONDITIONS. ORBIT FORGED STEEL ASA CLASS VALVES MEET THE TOUGH CONDITIONS FOR DEHYDRATOR SERVICE.

The efficient operation of a dehydration unit is dependent upon the proper selection of all components. Here valves are required to provide absolute shut-off under such conditions as cyclic operation, high differential pressures, and wide temperature ranges. In addition, valves must be free from stem leaks, be free from sticking or freezing, and be free from dust build-up on seating surfaces.

Selected to handle this tough job — Orbit Full Opening Forged Steel Valves. These valves provide full flow, friction-free resilient seating and there is no chance for line build-up or trapping of solids or line fluids because there are no body cavities. Particles of drying agent cannot get between seating surfaces because valve is self-cleaning and dust carryover is swept through valve by gas streams.

The maximum rated working temperature for Orbit's standard line of ASA class valves has been increased from 250° Fahr. to **400° Fahr.** Prices for these valves remain the same.

IN ADDITION Orbit ASA class valves are now available for **450° Fahr.** Maximum rated working temperatures in 150-300-400-600 lb. Class. Write us for prices.

Learn how Orbit Valves can help your installation by writing to our Industrial Sales Department.

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Orbit ASA Class Valves are available through your favorite Supply Store

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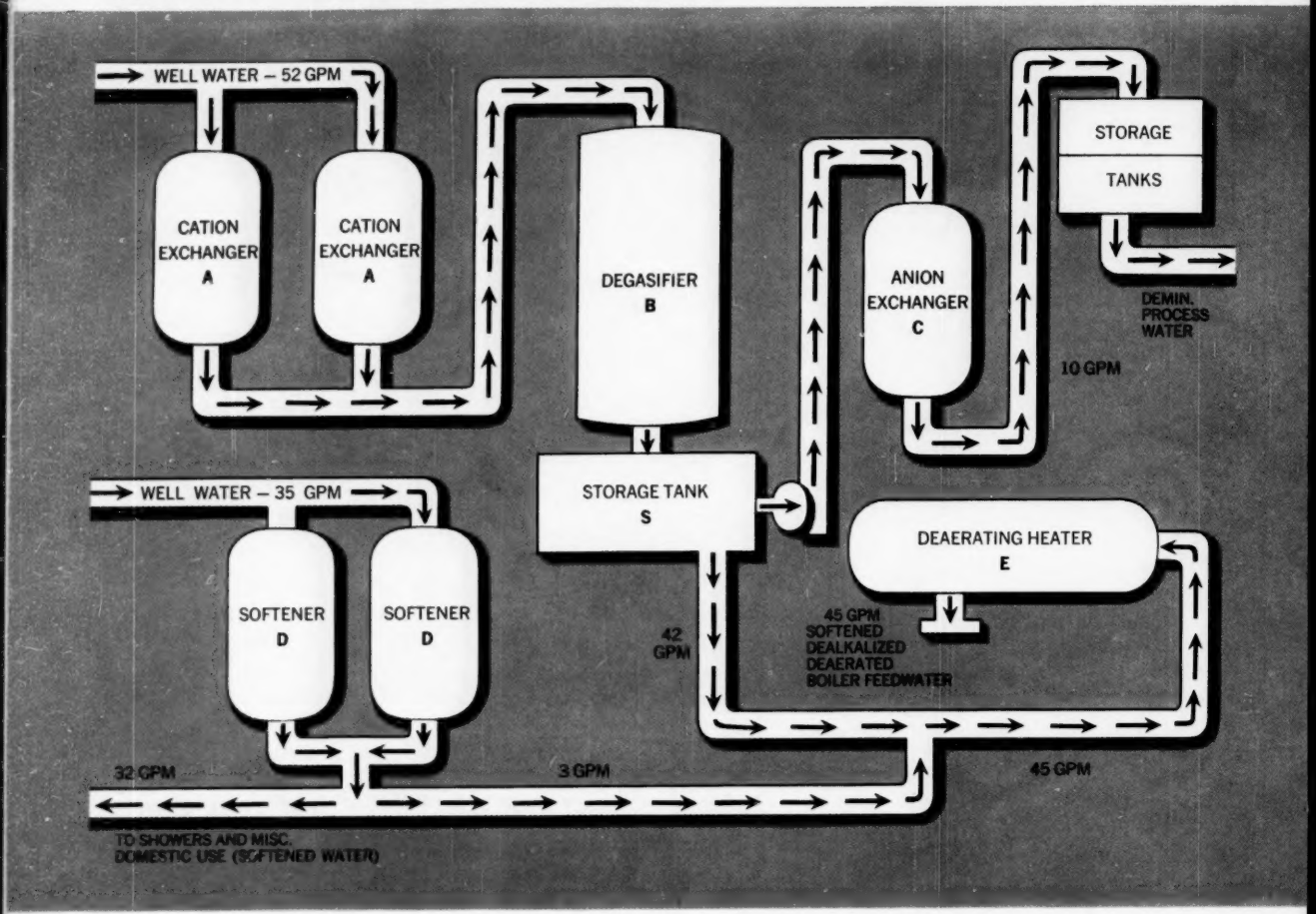
FLUIDICS* AT WORK



How to get three kinds of water from a single treatment system

This is a diagram of the water treatment system at the new Owensboro, Kentucky plant of Dewey & Almy Chemical Division of W. R. Grace & Co.

Only one kind of water goes into this plant: raw well water, with a hardness of 11.6 grains per gallon.

But the conditioned water that comes out is suitable to meet the demands of three different applications:

It's demineralized, for use as process water in the making of polyvinyl acetate emulsions and butadiene-styrene copolymers.

It's also dealkalized and deaerated, for use as boiler feedwater.

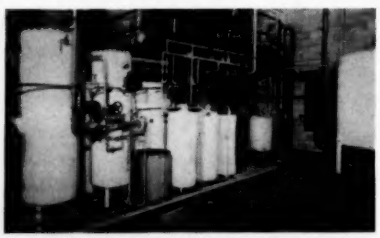
And it's softened, for general miscellaneous use around the plant – washing, employee showers, etc.

How it's done. To do all these jobs the water receives a progressive treatment in a compact Permutit system.

First the raw water is divided into two streams. One, of 52 GPM flow, is processed through two Permutit Q hydrogen cation exchangers (A) and then through a Permutit degasifier (B) into a storage tank. From this storage a 10 GPM stream is directed to an anion exchanger (C) where Permutit S-2 resin completes demineralization producing a finished process water.

Water for non-critical uses flows into the system at 35 GPM for treatment in two Permutit softeners (D) with Permutit Q resin.

Boiler feedwater requirement is 45 GPM so 42 GPM is supplied from storage (S) and three GPM from the softened supply. This water is blended and fed to a Permutit deaerating heater (E) which delivers it ready for boiler make-up.



Permutit water conditioning system occupies small space in corner at Dewey & Almy, yet processes every drop of water used throughout the plant.

Guaranteed results. When this system was installed, there was no question about the quality of the water it would produce. Results were *guaranteed* by Permutit. Such guarantees are possible because of our unusual position in the water conditioning field. Not only did we originate the ion exchange system of water softening, but we are also the only company to manufacture *both* the equipment *and* the ion exchangers for all types of water conditioning.

Your water problem? Your water needs may be anywhere on the spectrum of water conditioning – from simple soft water, to highly critical requirements that call for Permutit "ultimate" water.

In any case, chances are good that we can solve the problem at minimum cost.

As a start, send for a free copy of Bulletin 4433, "An Outline of Modern Water Treatment Equipment."

Permutit Division, 50 West 44th St., New York 36, N. Y.

PFAUDLER PERMUTIT INC.

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